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Next Month

Conroe has developed into a field of major proportions and is the greatest center of interest as well as the most active field in the country. Sidelights on the drilling and producing activities there will be a feature of our next issue. This information will be gathered on the spot by members of The Petroleum Engineer's editorial staff.

The first of a series of articles designed to assist in the solution of well-pumping problems is also scheduled to appear.

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ENTRY

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A Short-Sighted Economy Measure

By K. C. SCLATER

DRASTIC cuts in government appropriations this year may bring to a halt many important investigations in oil and gas now being carried on by the Petroleum and Natural Gas Division of the United States Bureau of Mines. It will be an unfortunate and incalculable loss indeed to all branches of the petroleum industry if this should happen. At no time has the need become more insistent than it is today for enlightenment on many problems requiring for their solution involved chemical and engineering research; technical research of the type that the personnel of the Bureau of Mines, with its far-flung facilities as a department of the Federal Government, is peculiarly well fitted to perform.

Organized in July, 1914, this division of the Bureau of Mines during its 18 years of existence has contributed in large measure to progress in the petroleum industry. Publications on oil and gas totaling almost 500 have been issued by the Bureau of Mines during this period. These bulletins and reports are the fruit of technologic and scientific investigations on the production, preparation, refining, methods of handling and use of petroleum and natural gas. They are regarded by petroleum technologists the world over as being among the most authoritative and valuable technical writings on petroleum and related subjects that have been published. It would be difficult to evaluate the benefits that have accrued to producers and refiners of petroleum through the dissemination of this knowledge. Anything that hints, therefore, of the drying up of this fountain of pertinent scientific information at its source is a matter of grave concern. It is the application and dissemination of this knowledge so painstakingly garnered from field investigations that has been the very life-blood of sound and healthy growth in the oil industry.

It is the purpose of the Bureau of Mines to foster, through its petroleum and natural gas division, the wise development and efficient use of the oil and gas resources of the country. Investigations are scrupulously confined to problems that are common to the entire oil industry and in which are involved studies of a fundamental nature that can not reasonably be undertaken by individual companies. It undertakes to lay the groundwork for future study on many special problems that have a broad national scope or significance.

To the producing branch it advocated, as far back as 1914, uniform casing programs, cementing of wells, and the use of peg-models and other devices as aids in the prevention and study of water encroachment in oil fields. Later investigations were concerned with the flow of fluids through sands, and oil-gas-energy relationships in natural sub-surface reservoirs. More recently, problems studied have included the solubility of gas in oil reservoir conditions of pressure and temperature. Work on this latter investigation was getting well under way when last year, owing to lack of funds, field work had to be suspended. So vitally important and timely was the information to be gained from further investigation of this problem that a group of oil companies requested assistance and lent financial aid so that field work could be carried on in the East Texas field by engineers of the Bureau of Mines on the solubility of gas in oil under reservoir conditions.

Methods developed by the Bureau of Mines for analyzing and classifying crudes are accepted as standard throughout the petroleum industry.

Wasteful open-flow methods for testing the capacity of gas wells have been supplanted by back-pressure methods developed by engineers of the Bureau of Mines. In the Texas Panhandle fields alone the testing of 221 wells by the back-pressure method has resulted in an estimated minimum saving of 114,000,000 cu. ft. of gas each time the wells are tested.

Field and laboratory investigations on natural-gas transmission have yielded data that have served as a guide in the construction and operation of every large natural-gas transmission line laid since 1928. Also from the conscientious labors of these same natural-gas engineers of the Bureau prodigious savings have been made by applying the procedure and data developed by them for the detection of leakage losses in natural-gas transmission lines.

From 1914 to 1932 the capital investment in the petroleum industry increased from $500,000,000 to $12,000,000,000, a 24-fold increase in 18 years. With this expansion the problems calling for solution have also increased in kind. Since 1925 the tendency has been to curtail the work of the Petroleum and Natural Gas Division of the Bureau of Mines. This year it may be that most of the problems within the industry that are demanding immediate solution and on which several years' work has been completed will have to be suspended. This despite the fact that the continuation of these researches is vital to the future welfare and progress of the entire industry.

Research has been and will continue to be the salvation of the petroleum industry.

With such a brilliant record of accomplishment and all that the industry owes to research it seems nothing short of absolute folly to cut off or suspend these researches under the guise of an economy measure. It's like killing the goose that lays the golden egg.

HIGHLIGHTS in OILDOM

Crude Prices Again Lowered

A new low crude oil price scale was established January 18 in the Mid-Continent by the Stanolind Crude Oil Purchasing Company, which action was joined by other crude purchasers within a few days. The reduced schedule calls for payment of 52 cents per bbl. top price and a 2-cent per bbl. differential for each lower degree of gravity to a bottom price of 28 cents for oil of below 29 gravity. This posting compares with the previous one of 77 cents per bbl. for 40 gravity and above oil with a price range to a bottom scale of 53 cents for below 29 gravity crude. A flat price of 50 cents per bbl. was established for all oil purchased in the East Texas field.

According to a prepared statement of the Stanolind Company, general chaotic conditions prevailing in the oil industry necessitated the additional reduction of crude prices. The company enlarged on the foregoing statement by stating that the inability of state officials to enforce proration regulations, the large amount of crude oil going at "bootleg" prices, evasion of gasoline taxes and the refining and marketing of "bootleg" oil and gasoline at prices below normal market prices were factors against which they had no effective way of protecting business except by meeting the prices created by such agents.

All Pennsylvania oils were cut 15 cents per bbl. the following morning and this action immediately led to posting of lower price schedules in Central Western fields, Canadian and Rocky Mountain regions.

Proration Enforcement Under Investigation

Investigations of the enforcement of production proration regulations are being conducted in both Oklahoma and Texas. Apparently, an abundance of evidence has been given showing that vast quantities of crude oil have been produced, sold and transported to markets, in excess of the allowable outlet permitted under state curtailment policies. These investigations are largely the result of continued reports of such movements of oil and were pushed into the foreground by the recent price cut.

Some startling evidence has been unearthed at Oklahoma City, including an admission of over-production by one oil company official and a statement from a refinery representative that his company had purchased more than 500,000 bbl. of so-called "hot" oil. In practically every case where overproduction has been admitted, investigators have discovered that the oil was sold for prices below posted schedules.

While these investigations may not result in any concrete improvement, they have at least removed the rumors of such "rackets" from strictly talk to verified statements.

California Production Reduced to Allowable

The attempt to secure effective curtailment in California was a step nearer success when on January 30, according to the umpire's official reports, California crude production was 442,990 bbl. This is the second time since the 440,000-bbl. quota was agreed upon as the state allowable production that its output has approximated the desired figure. Huntington Beach operators led all pools in slicing 18,810 bbl. from the state's daily recovery by curtailing nearly half this amount. This field has persistently been exceeding its daily quota by a considerable margin because of competition in the town lot area.

Oklahoma Commission May Enjoin Operators from Violating Orders

A more powerful weapon for enforcing production curtailment was placed in the hands of the Oklahoma Corporation Commission when the state supreme court ruled that district courts have authority to enjoin operators from violating commission orders issued lawfully.

The court, however, held that the Governor, through the state militia, was without authority not only to assume control of the oil field but also is without authority to impose a tax upon operators to maintain the national guardsmen employed to enforce the commission's rulings.

Federal Inquiry Into East Texas Tax Evasion

The Federal Government has taken cognizance of repeated charges that many plants in East Texas are evading gasoline taxes, as shown by the arrival of six representatives of the Collector of Internal Revenue from Dallas. These agents are endeavoring to develop a check-up on taxes that have accrued, but allegedly in arrears since the tax went into effect June 21, 1932.

To Permit Closer Spacing in East Texas

The Texas Railroad Commission, effective January 31, 1933, issued a revised spacing rule for the East Texas field that is designed to permit somewhat closer spacing of the wells in order to increase the ultimate recovery of the field, according to the commission. The rule permitting the drilling of only one well to each 20 acres has been replaced by one allowing the drilling of wells 660 ft. apart, or approximately one well to each 10 acres. It is too early yet to know how many operators will take advantage of the new spacing program and to determine even approximately the number of additional wells that will be drilled.

Oklahoma Would Make Illegal Producing a Felony

A bill that would make it a felony punishable by imprisonment illegally to produce and deal for oil produced in excess of proration allowables has been passed by the Oklahoma State Senate. It must pass the house before going to Governor Murray.

1932 Motor Fuel Consumption Decline Not as Sharp as Anticipated

Decline in consumption of motor fuels in 1932 was not as great as the industry had feared, it is indicated by figures compiled by Fred Van Covern, staff statistician of the American Petroleum Institute.

The total decline amounted to about 41,000,000 bbl., or 9.2 per cent, as compared with the 1931 figure, and the domestic consumption was only 7.8 per cent. In 1931, domestic consumption amounted to 407,843,000 bbl., which was a new record, and 2.6 per cent increase over 1930. In 1932, domestic consumption amounted to 376,078,000 bbl. Exports declined from 45,716,000 to 35,831,000 bbl., a falling off of 21.6 per cent. A total of 411,090,000 bbl. was consumed during 1932.

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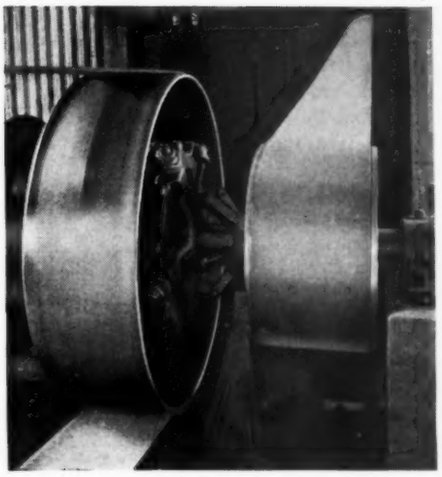

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Latest Activities in the Oil Fields

INCREASING activity in the Conroe field of Montgomery County, Texas Gulf Coast, was a feature of developments during the past month. This pool now has more than 125 active operations and bids fair soon to overtake the declining East Texas field as the most active territory in the Nation.

The past month saw the sharpest drop yet registered in operations of the East Texas pool, when only 158 drilling permits were issued; a short time ago as many were issued every week.

Two important developments in the play centering around Duval County, South Texas, were the discovery of gas production by two wildcat tests that greatly enhanced the already brilliant outlook for greater production. One of these wells is located eight miles southwest of the Sarnosa field, the outlying pool in that direction in the Government Wells string, while the other lies seven miles east of the Government Wells pool.

The wildcat play in Texas continues to spread, particularly in Southern and Gulf Coastal regions. In South Texas new drilling operations continue to be reported in all sections, with every county having at least one wildcat rig running. Sixteen counties in the Texas Gulf Coast are the sites of wildcat operations.

In Oklahoma, attention was centered on two wildcat tests in Noble County, which apparently have extended the new Wentz pool. Initial showings indicate that at least one of the wells is as good as the discovery well. This test is over a half mile northwest of the original well and is flowing approximately 50 bbl. per hour. The second well, located 2¾ miles southeast, was making approximately 10 bbl. an hour from the upper pay sand. These developments indicate that the producing horizon of the Wentz field may be larger than earlier expectations and that continued drilling may find the anticipated high recovery predicted by several prominent geologists.

The fourth producing completion has been in Miller County, Ark., where a new play has been budding. The new producer is a south offset to the three previously completed wells. The well is good for 350 bbl. per day with considerable water. Thus far the results obtained in the pool have been somewhat disappointing, but drilling continues to be very active.

The lack of connections for completed wells in Western Kansas has practically terminated the wildcat campaign of that region and activity is again shifting toward Eastern Kansas, where production is shallower and it is easier to obtain pipe line connections. Although Western Kansas appears to be the most promising potential producing area it may be temporarily forced into the background because of its remote location from pipe lines.

Another state that is receiving considerable wildcat exploration is Michigan, where 14 scattered portions of the state are being tested at this time.

Apparently two tests on the North Dome at Kettleman Hills, Calif., are failures. Both wells further indicate the producing limits of the field.

AVERAGE CRUDE OIL PRICES

California		Oklahoma	.44
Playa Del Rey	$ .78	Arkansas	.25
Coalinga	.55	Louisiana	
Long Beach	1.00	North Louisiana	.44
Montana	.75	Gulf Coast	.54
Wyoming	.44	Illinois	.62
Colorado	.40	Kentucky	.57
New Mexico	.30	Indiana	.40
Texas		Ohio	
North Central	.44	Lima	.70
Panhandle	.38	Wooster	.70
West Texas	.30	Michigan	.85
Gulf Coast	.54	Pennsylvania	
Darst Creek	.35	Bradford	1.47
East Texas	.50	Corning	.70
Kansas	.44	West Virginia	1.12

Production and Refining Figures Furnished by the American Petroleum Institute

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending January 28, 1933

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbls.	Gas and Fuel Oil Stocks Thousands of Bbls.
East Coast	99.1	472,000	73.9	12,885	7,835
Appalachian	95.0	81,000	60.0	1,875	933
Ind., Ill., Ky.	97.5	300,000	70.8	7,396	3,344
Okla., Kans., Mo.	84.9	195,000	50.0	4,882	2,895
Inland Texas	56.4	82,000	46.1	1,524	2,248
Texas Gulf	97.7	416,000	76.8	6,281	6,456
Louisiana Gulf	97.3	87,000	61.3	1,532	2,384
No. Louisiana-Ark.	88.5	40,000	50.6	304	503
Rocky Mountain	90.8	32,000	23.2	1,250	495
California	94.6	393,000	45.4	15,282	99,116
Total Jan. 28, 1933	91.6	2,098,000	59.4	53,211	126,209
Total Jan. 21, 1933	91.6	2,106,000	59.6	52,547	126,025

Daily Average Production

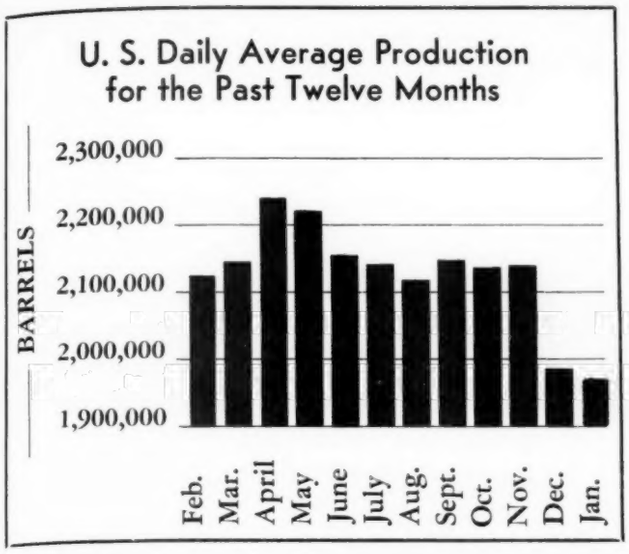
(Figures in Barrels)

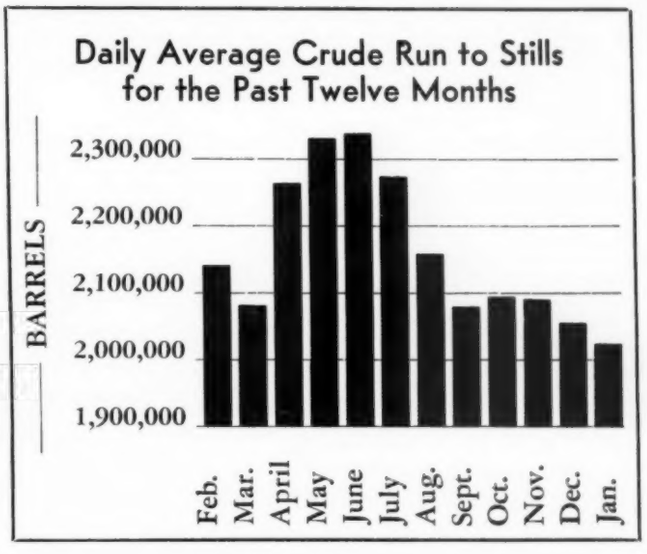
	Week Ended Jan. 28 1933	Week Ended Dec. 31 1932	Week Ended Jan. 30 1932
Oklahoma	370,100	336,900	411,700
Kansas	94,100	89,850	97,900
Panhandle Texas	46,200	44,450	52,850
North Texas	46,250	47,300	49,350
West Central Texas	24,400	24,250	25,950
West Texas	157,800	156,550	173,750
East Central Texas	48,500	50,150	49,750
East Texas	294,100*	(a)	332,750
Southwest Texas	51,650	52,200	52,100
North Louisiana	29,900	29,500	29,050
Arkansas	32,150	32,800	34,300
Coastal Texas	134,500	131,500	111,800
Coastal Louisiana	34,400	33,950	28,450
Eastern (not including Mich.)	89,900	92,950	106,600
Michigan	15,300	17,500	14,450
Wyoming	31,300	29,850	35,650
Montana	5,500	5,900	5,850
Colorado	2,700	2,700	3,650
New Mexico	36,550	27,850	37,000
California	463,400	472,600	508,600
TOTAL	2,008,700	1,698,000	2,161,500

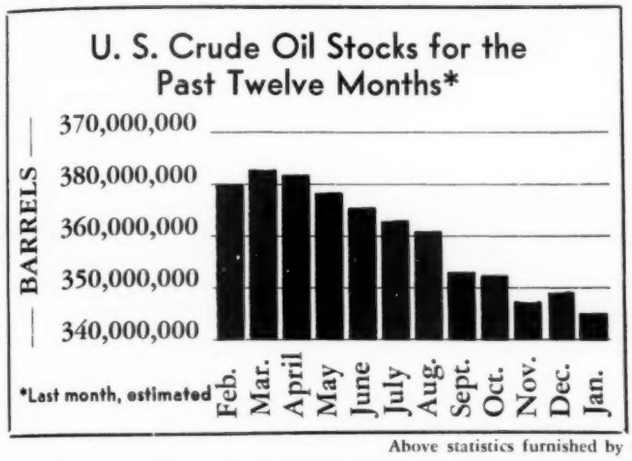
(a) East Texas entirely shut in.

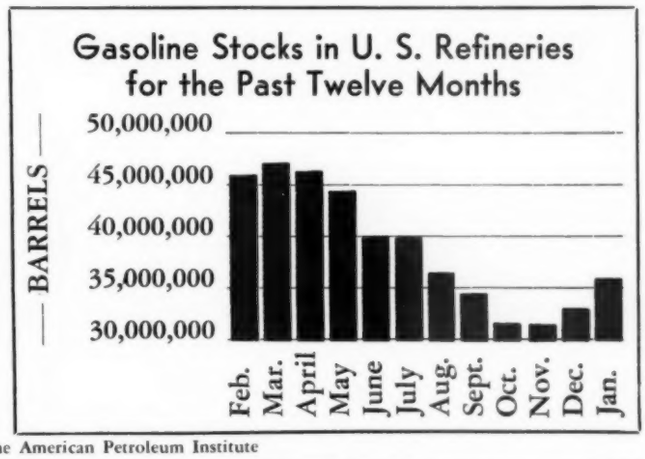
* These figures reflect only that oil produced in accordance with proration allowables and does not include oil produced under protection of injunctions or otherwise.

NOTE: Stocks at refineries, except in California district, which includes stocks on finished gasoline and engine distillate at refineries, water terminals and sales distributing stations and amounts in transit thereto.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for January, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	216	215	158	86	125	3600	2	40	Rotary
Duval County	30	24	20	10	41	2300	2	22	Rotary
Conroe	50	49	79	29	87	5200	2	38	Rotary
Oklahoma									
Oklahoma City	11	11	4	3	15	6500	3	39	Rotary
Kansas									
McPherson	14	12	13	12	46	2900-3400	2	38	Rot.-Cab.
Ellsworth Arch	10	6	7	9	30	3300	4	37	Cable
California									
Kettleman Hills	0	0	1	2	12	8300	3 or 4	40	Rotary
Long Beach	6	6	4	7	12	7000	3	26	Rotary

Field Activities by States for January, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	4	4	0	0	25	3	13	10	37	23	11,907,000
California	20	21	17	20	16	21	7	10	82	99	178,128,000
Colorado	2	1	1	1	1	1	6	9	56	71	1,177,000
Illinois	2	0	1	0	....	....	1	1	12	10	4,661,000
Indiana	18	19	7	14	....	....	2	1	64	70	804,000
Kansas	40	45	26	26	39	53	46	40	107	102	34,300,000
Kentucky	20	30	18	18	....	....	15	6	56	48	6,264,000
Louisiana	29	41	12	15	26	45	37	39	119	105	21,478,000
Michigan	16	20	13	15	17	19	35	53	66	67	6,729,000
Mississippi	1	2	1	2	....	3	1	2	10	14	Gas. Prod.
Montana	2	5	2	4	3	4	7	9	40	52	2,449,000
New Mexico	6	10	5	9	13	10	4	12	49	56	12,511,000
New York	3	11	2	11	....	....	2	3	8	8	3,501,000
Ohio	56	67	49	54	....	....	37	25	108	121	4,597,000
Oklahoma	87	100	52	63	84	115	115	118	304	339	152,621,000
Pennsylvania	38	51	33	45	....	....	6	9	93	65	12,403,000
Texas	473	712	362	577	454	692	297	320	882	951	311,069,000
West Virginia	27	24	21	17	....	....	10	20	34	42	4,472,000
Wyoming	1	2	1	2	....	....	9	9	69	71	13,359,000
Total	845	1166	623	705	678	976	651	696	2196	2315	781,845,000

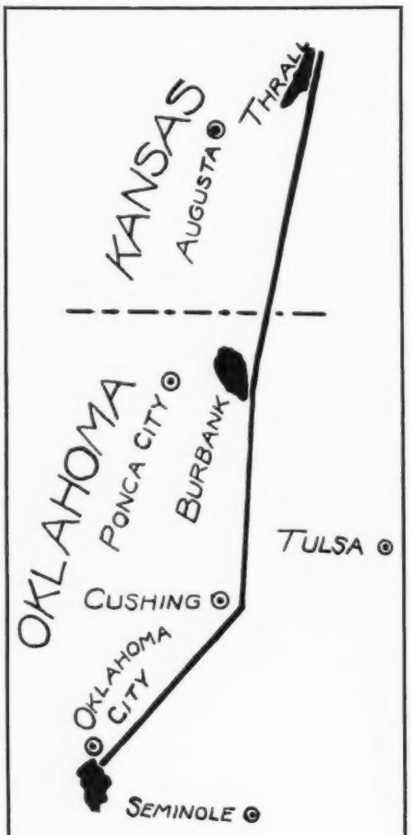
Progress of Major Pipe Line Work

By WARREN L. BAKER

THE most important pipe line construction work in several months was announced during the past 30 days. Reports that several transmission systems would be enlarged were confirmed and numerous rumors concerning other contemplated lines are afloat. The majority of new lines to be laid were for the purpose of connecting principal producing areas with refinery transmission systems or for transporting gasoline from refineries to markets.

Crude Oil Lines

So little construction work on transmission lines has been done in recent months that the sudden flurry of activity has aroused unusual interest. The most important line in the point of mileage is the 8-in. electric welded extension of the Phillips Petroleum Company's Kansas system from Thrall, Greenwood County, Kansas, to the Oklahoma City field, a distance of approximately 210 miles. The routing of the line is such that it also makes available outlet facilities for important producing properties at Burbank and Cushing.



Routing of Phillips Petroleum Company's 8-in. Line from Thrall to Oklahoma City

The Phillips Company has huge potential production in the Oklahoma City pool and with the completion of this line its principal Oklahoma production will be connected with the company's Kansas City refinery, where improvements are being made. Work has been started on the laying of the line by the contractors, Kelly-Dempsey Company, some of the pipe having been shipped by the Republic Steel Corporation, whose product is being used on the entire project. H. C. Price, Inc., of Bartlesville, Okla., was awarded the welding contract. It is rumored that the company plans to loop its 6-in. line from Thrall to Kansas City, a distance of about 100 miles, but no definite announcements have been made to this effect.

The Tide Water Pipe Line Company will soon have an outlet for its production in the new Conroe, Texas, field. The company's 20-mile 8-in. line from the field to pipe line connections at Humble is expected to be completed this month. Apex Construction Company is doing the work on this line.

The Lario Oil Company is laying a 20-mile 4-in. line from Galva in the Ritz-Decker-Canton pool to the Globe Oil and Refining Company's newly completed refinery at McPherson, Kan.

The Texas Pipe Line Company has shipped 10 miles of 4-in. pipe to the Government Wells pool in Duval County, Southwest Texas.

It is understood that the Wilcox Oil and Gas Company is considering the building of a pipe line from production in the Oklahoma City field to its refinery at Bristow, Okla. The distance is about 75 miles and the line, if built, is likely to be either 6-in. or 8-in.

Gasoline Lines

Two important gasoline lines are to be laid in Kansas, giving impetus to the program for more widespread use of pipe lines for transporting gasoline to markets. The Globe Oil and Refining Company has under way a survey for the longer of these —a line from its refinery at McPherson, Kan., to Superior, Neb., a distance of approximately 140 miles. The Derby Oil Company recently announced plans for the laying of a gasoline line from its Wichita refinery to a gasoline terminal now being constructed at McPherson. This distance is approximately 60 miles.

Natural Gas Lines

The John W. Moore Construction Company, Lubbock, Tex., plans the laying of a natural-gas transmission line to serve Lubbock, where the company was recently granted a franchise. The franchise agreement calls for the starting of the line by May 15, 1933, and service must begin not later than November 1, 1933. The Hobbs field, approximately 100 miles distant from Lubbock, will be the source of supply.

Greater facilities for handling the large gas production of the West Holdenville pool, Hughes and Seminole counties, Oklahoma, are being provided by the Phillips Petroleum Company, which is laying a 10-in. line from its gasoline plant southeast of Wewoka to the field, a distance of five miles, and by the Empire Gas and Fuel Company, which is now running gas through its new 6-in. line.

Plans are practically complete for the construction of an 80-mile 10-in. line from the Sunbright gas field in Tennessee to Knoxville, Maryville, Harriman, Kingston and Lenoir City, Tenn. S. H. Jones, president of the Public Service Company of Sunbright, has stated that construction will begin within 30 to 60 days days, the state utilities commission having granted permission to build the line.

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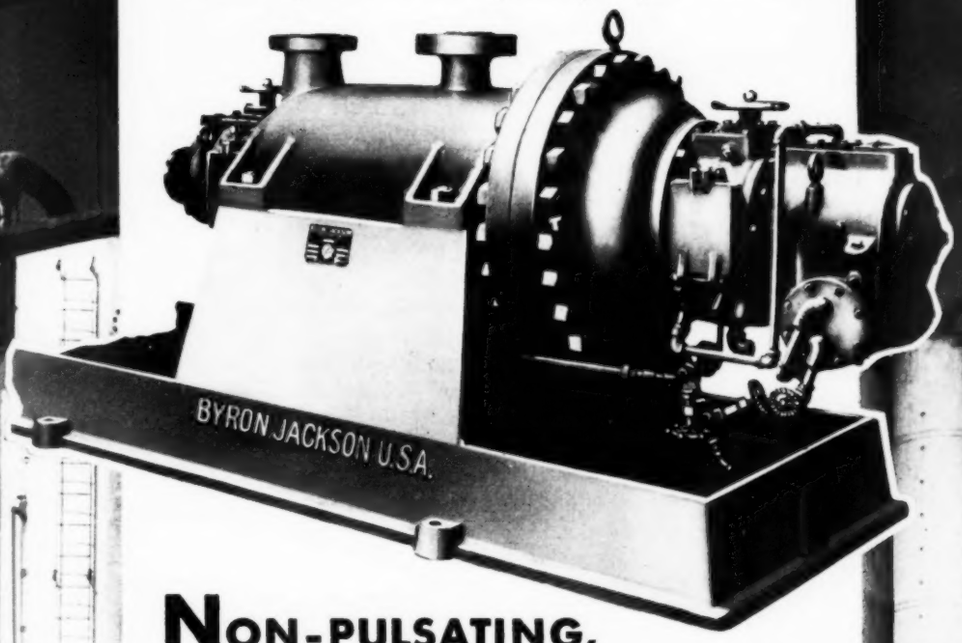

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The Month's Activities in Refining*

By F. R. STALEY

THE PHILLIPS PETROLEUM COMPANY has awarded an order for four heavy welded vessels with 1¾-in. shells and heads to be used as cracking units in the Borger, Texas, and Kansas City, Mo., refineries to the Henry Vogt Company.

A 1000-bbl. refinery is planned for the new Miller County oil field to be erected near Texarkana, Ark.

The Huasteca Petroleum Company, subsidiary of the Standard Oil Company of Indiana, will build a modern refinery at Tampico, Mexico.

The Hi-Way Oil Company is building a small refinery at South Westminster, B.C., Canada, on the Fraser River.

The Continental Oil Company is planning the installation of a Kellogg cracking unit in its refinery at Glenrock, Wyo. This refinery has a crude capacity of 7500 bbl. daily.

The Associated Oil Company will spend a million dollars on plant expansion this year. Work has been started on a new cracking plant at the Avon, Calif., refinery.

Negotiations directed toward the broadening of its license contract with the Standard Oil Company of Indiana, covering cracking equipment, have been concluded by the Ohio Oil Company. New plant construction, in line with the broader scope of processing, was authorized by the Ohio Oil Company, following the license negotiations. Through its subsidiary, the Marathon Oil Company, it contracted with the M. W. Kellogg Company to install a 1500-bbl. cracking unit, for processing gas oil or topped crude at their Fort Worth, Tex., refinery. Contract was also made to install a unit of similar capacity in the Bristow, Okla., refinery.

The Yaciminetos Petroliferos Fiscales has been authorized to add a fourth unit to the cracking plant at the La Plata refinery, with the object of obtaining a better yield of gas oil and gasoline from the crude.

The Compagnie Francaise de Raffinage, a branch of the Compagnie des Petroles, is constructing a petroleum refinery at Gonfreville Caillot, France, which it is planning to put into operation early this year. During the first two years this refinery is to have an annual production capacity of 700,000 tons of crude, which is to be doubled later.

Globe Oil & Refining Company will enlarge its Lamont, Ill., refinery. Winkler Koch Engineering Company has been awarded the contract. The Henry Vogt Company has recently completed the installation of additional boilers at this plant.

Research experts of the Standard Oil Company of Indiana have prepared a discussion of the subject of the use of alcohol in motor fuel. This company is in an essentially neutral position in regard to the idea. It could take up as easily as anyone the manufacture of industrial alcohol from farm products to replace part of its gasoline. Complications, however, make the idea look highly impracticable. Conditions fundamentally different in this country from those in countries where alcohol is used in motor fuel change the outlook for its possible use here.

Natural Gasoline

The Moran Crosby Oil Company of Tulsa will erect a natural gasoline plant in the West Holdenville field, Okla.

Figures in red show per cent refining capacity operated.

*All statistics as of Feb. 1.

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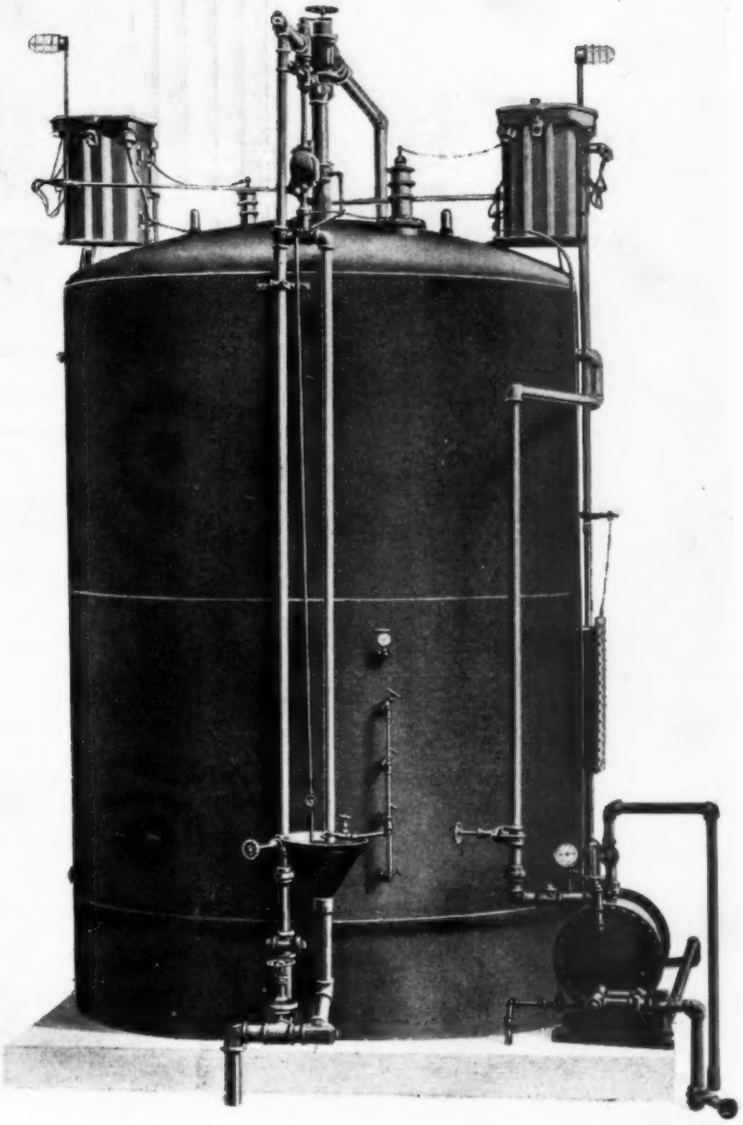


PETREKCO

The Electrical Process for Dehydrating Crude Oil Emulsions.

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA
Security Title Insurance Building., Los Angeles. Branch: Houston, Texas

Intermittent F

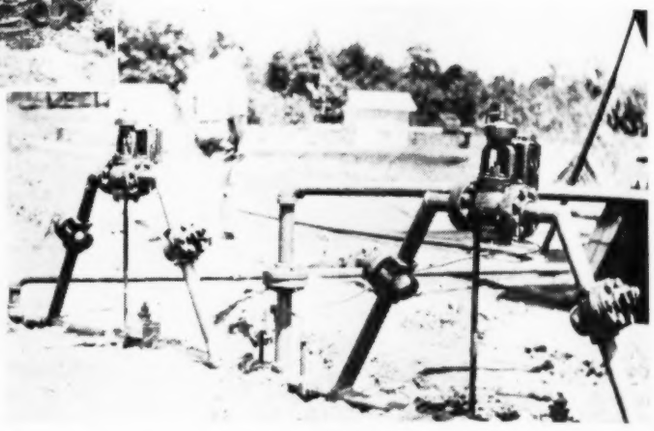
By

S. F. SHAW

Consulting Engineer

San Antonio, Texas

Max-i-Flo Intermitter on 400-ft. well in Northern Oklahoma



Input and discharge valves and method of connecting up may be seen on this installation of magnetic valves

INTERMITTENT flowing of oil wells has been practiced on a small scale for many years. Stirling[1] calls attention to the fact that wells in the Corsicana field were operated on intermittent, or periodic, flow in 1899. In Oil City, Penn., the intermittent flowing of oil wells has been carried on in a group of wells for perhaps 25 years. In these Oil City wells the daily production is very small and the wells are flowed once each day by manual control by an operator who "blows" out the wells with a compressor situated in a near-by wagon manufacturing plant. In the early part of 1926, intermittent operations were under way on properties of the Comar Oil Company in the Braman field, Oklahoma, under the direction of Reid W. Bond.

Intermittent operations have been studied and systematized in various California oil fields and in some of the Mid-Continent fields during the past four or five years, and excellent results are being obtained. This method of flowing wells has also been employed for some time on the island of Trinidad.[2] At the present time, to the writer's knowledge, intermittent flowing of oil wells is being practiced in California, Indiana, Kansas, Oklahoma and Texas, also in Argentine, Peru, Poland and Roumania.

It would appear that the method has received a wide-spread application, particularly for small wells and where low lifting costs are required. However, the quantity of oil lifted in most of these wells is so small compared with the production lifted by the usual continuous gas-lift operation that little attention has been paid to it. The method, moreover, requires more technical knowledge, both in its installation and operation, than pumping; consequently the field man feels more at home in using the beam pump than in undertaking to handle a method not well understood. It is believed that, in the course of time, the necessity for lower operating costs and the desire to produce all the oil that the well will make, will lead the oil companies into a careful study of this method.

There are two types of intermittent flowing in use at the present time.

1 The periodic flowing of the well through tubing or casing, similar to the starting of a well that is flowed by continuous gas-lift. In this type of operation, no chamber is placed at the bottom of the well, and no standing valve is necessary at the lower end of the flow column.

2 The use of two concentric strings of tubing within the casing, with a chamber of enlarged diameter attached to the lower end of the outer string of tubing, and with a standing valve set in the lower end of the chamber. The air or gas is periodically admitted to the annular space and the oil displaced from the chamber into the inner string of tubing, through which it is lifted to the surface. A sketch of the make-up of the chamber and tubing arrangements accompanies this article.

The first type of intermittent flow is more common in the larger wells. Conditions of pressure and of obtaining the maximum production of oil in wells of 3000 or 4000 ft. in depth appear to make it desirable to flow wells producing more than 150 bbl. of oil per day by this type of intermittent flow. It has been found that in some wells making up to 500 or more bbl. of liquid containing 50 to 75 per cent water, there is less emulsion formed by intermittent flow than when flowing such wells on continuous gas-lift and the emulsion so formed is less difficult to treat. It has also been observed in several cases when lifting a mixture of oil and water that the quantity of input gas required per bbl. of liquid lifted is smaller than when producing this mixture by continuous gas-lift.

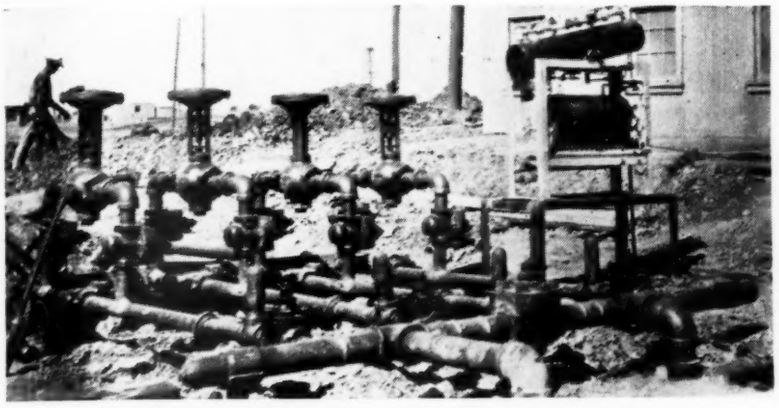
The second type of intermittent flow is employed to advantage when the wells have declined to less than 150 bbl. per day. The consumption of gas per bbl. lifted has been found to be less when using the second type than when using either continuous flow or the first type of intermittent flow. How-

[1] Robert Stirling, "The Air-Lift System of Raising Oil," Journal Inst. Pet. Tech. (London) Vol. 6, pp. 379-406 (1920).

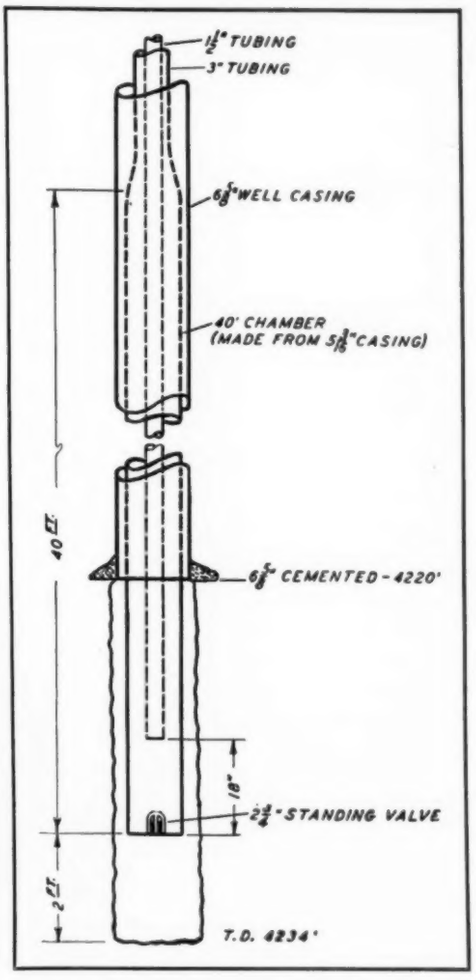
[2] Albert Millar, "Displacement Pumping as Applied to Oil Wells," Journal Inst. Pet. Tech. (London), Vol. 18, pp. 445-476 (June, 1932).

Flowing of Wells

Necessity for Lower Operating Costs Gives New Impetus to Study of This Method



National Intermitter and Diaphragm Valves Hook-up used on four wells 4000 ft. in depth



Sketch showing chamber and the tubing arrangements for flowing wells intermittently by Method 2

ever, more attention must be paid to the design of tubing and other flowing arrangements in the second type than when using the first type.

The use of intermittent flow, especially for the smaller wells, bids fair to receive increased attention as wells increase in depth. Continuous flow can be employed to advantage in wells of any depth even to 10,000 ft. or more, provided the production is greater than 200 to 500 bbl. per day. As production declines below 200 to 500 bbl. per day, which figure depends largely on the depth of the well, it will probably be found that lower operating costs can be obtained by changing from continuous to intermittent flow.

An illustration of the costs incurred in continuous flow for a small well of 4000 ft. in depth as compared with a well of the same depth employing intermittent flow will be mentioned. For example, a well 4000 ft. in depth, lifting oil of 41 deg. A.P.I. gravity at the rate of 100 bbl. per day through 6⅝-in. casing required a total output factor of 14,000 cu. ft. per bbl. when on continuous flow. The gas-oil ratio was negligible so far as lifting was concerned, that is, between 500 and 1000 cu. ft. per bbl., leaving the input gas factor at approximately 13,500 cu. ft. per barrel. A fair cost for compressing gas either in large or small efficiently operated plants where free gas is available for fuel is 3 cents per 1000 cu. ft. The cost of continuous gas-lift operation through 6⅝-in. casing under these conditions would then be 3 × 13,500, or 40½ cents per barrel. If the oil were lifted through 4-in. tubing, the output factor would be approximately 8500 cu. ft. per bbl. and the input factor would be about 8000 cu. ft. per bbl., thereby making for a gas-lift charge of 3×8, or 24 cents per barrel. On intermittent flow, with chamber at the bottom of the well, a fair figure for input gas would be 3000 cu. ft. per bbl., thus obtaining a gas-lift charge of 9 cents per bbl. lifted. The difference between 9 cents per bbl. on intermittent flow and 40½ cents on continuous flow through 6⅝-in. casing or 24 cents through 4-in. tubing is so great that there is no doubt as to the method to adopt, in fact, it would appear as if the use of intermittent flow should be adopted considerably before the production declined to 100 bbl. per day.

Some data with use of the first type of intermittent flow are given in Table I.

Examples of intermittent flow are given by Morgan Walker,[3] in which the production of liquid ranged from 1350 to 285 bbl. per day, and the input volume per bbl. of liquid ranged from 666 cu. ft. per bbl. in the case of the 1350-bbl. well to 2030 cu. ft. per bbl. in the case of the 285-bbl. well.

Data on intermittent flow of the second type are given in Table II. The 2-in. tubing in the first five examples is of greater diameter than necessary, but was employed to avoid the expense of purchasing a new string of tubing of 1½-in. diameter, which would be the proper size, and to avoid the expense of turning down slightly the collars on the 1-in. inner tubing in order that they would pass freely inside the 1½-in. tubing.

Assuming the cost of compressing gas to be 3 cents per 1000 cu. ft., the gas-lift costs on wells operated with input factors noted in Table II would range from 6 cents to 13½ cents per barrel. Costs for lifting oil in Trinidad[2] in a well

[3] Morgan Walker, "Intermittent Injection of Gas in Gas-Lift Installations," Trans. A.I.M.E., Vol. 82, Pet. Dev. & Tech., 1928-1929, p. 158.

TABLE I

Data on Intermittent Flow Through Annular Space or Tubing Without Chamber

Well	Casing Diam.	Tubing		Bbl. per Day	Time Interval in Min.		Input Gas per Bbl.
		Diam.	Length		Gas On	Gas Off	
A	6⅝"	2½"	4140 ft.	325	.....	.....	3000 cu. ft.
B	6⅝"	2½"	4120 ft.	180	.....	.....	4900 cu. ft.
C	6⅝"	2½"	4070 ft.	185	.....	.....	5380 cu. ft.
D	6⅝"	2½"	4330 ft.	670*	14	12	950* cu. ft.
E	6⅝"	2½"	4400 ft.	180	.....	.....	7000 cu. ft.
F	6⅝"	2½"	4290 ft.	510*	14	12	2625* cu. ft.
G	6⅝"	2½"	4140 ft.	565	8	9½	1126 cu. ft.
H	6⅝"	2½"	4130 ft.	780*	10	5	1466* cu. ft.
I	6⅝"	2½"	4050 ft.	70	.....	.....	9000 cu. ft.
J	6⅝"	2½"	4230 ft.	250	.....	.....	6200 cu. ft.
K	6⅝"	2½"	4400 ft.	105	.....	.....	6000 cu. ft.
L	6⅝"	2½"	4180 ft.	350	.....	.....	685 cu. ft.
M	6⅝"	2½"	4200 ft.	295	.....	.....	783 cu. ft.

*In these examples water was produced with the oil and the production as stated included the water; the input factor applied to the total barrels of fluid lifted, not for oil alone.

1000 ft. in depth by the chamber method of intermittent flow at the rate of 18 bbl. per day are stated to be 3 cents per barrel.

Intermitters

The intermitters in more general use in the Mid-Continent field are: National Tank Co. (Jackson) intermitter; Jat intermitter; and the Max-i-flo intermitter.

The National intermitter is usually located in a central position with reference to several wells and has capacity for 12 wells on intermittent flow of the first type and for six wells on the second type. In wells making more than, for example, 25 bbl. per day, it is necessary to provide for a sufficient number of cycles per day to produce the oil. This makes necessary the withdrawal of a large percentage of the compressed gas at the end of each cycle that is contained in the surface line between the two tubing strings. Unless this withdrawal of gas were made, the standing valve would not open in time sufficient to allow the chamber to become filled with the necessary load of oil.

The Jat intermitter is also located in a central position from which electric wires are extended to the various wells being operated. A magnetic valve located on the surface close to the well is controlled by the intermitter. The Jat displacement pump is sometimes employed in connection with the Jat intermitter, and is installed in the tubing close to the chamber, and so controlled by springs that it will close when the pressure in the chamber has dropped to a pre-determined point. By this means the compressed gas is retained in the annular space.

The Max-i-flo and its predecessor, the Smallomatic valve, have been employed in fields in Oklahoma, Kansas and Indiana, and in Argentine and Roumania. This valve is placed at the well and is operated by the rise of the fluid level in the well, which seals off the escape of gas from the pilot tubing that is hung in the well, thereby operating the input valves. This intermitter is automatic and operates independent of any additional control and independent of any other wells.

Quantity of Gas Required to Lift Oil With Intermittent Flow

The quantity of input gas required to lift a barrel of oil in a well 2900 ft. in depth operating at the rate of 20 bbl. per day, with outer tubing of 2-in. diameter, inner tubing of 1-in. diameter, and with 600 ft. of 2-in. line pipe between the intermitter and the well, is approximately as follows:

	Cu. ft. input gas/bbl.	*Pct. of total gas consumed*
Consumption gas in inner tubing	759	23%
Consumption gas in annular space bet. 1-in. and 2-in.	1881	57%
Consumption gas in 600 ft. of 2-in. line	660	20%
	3300	100%

If the diameter of outer tubing in the well were reduced to 1½-in., the consumption of input gas due to that left in the annular space at the end of each cycle would be reduced from 1881 cu. ft. to 696 cu. ft. per barrel. This is a reduction of 1185 cu. ft. per bbl., and would reduce the gas-lift charge from 9.9 cents per bbl. to 6.6 cents per barrel. The gas actually used in the inner tubing is only 23 per cent of the total consumption. If a valve that was dependable at all times were installed at the bottom of the well and would close off the admission of gas at exactly the correct time, the gas-lift charge would be reduced to approximately 2½ cents per barrel. If 1½-in. outer tubing were employed, and if a valve were employed at the top of the well that would close off at the proper time, the consumption of gas would be approximately 1500 cu. ft. per bbl. in the above example, and the gas-lift charge would amount to 4½ cents per barrel.

Uses of Separators with Intermittent Flow

Where the consumption of input gas amounts to the quantities noted in Tables I and II, there is an excess of gas available for moving the oil through a flow line on the surface of considerable length, consequently there is not much need of placing a small separator at each well to receive the flow. If, however, a control valve were placed at the bottom of the well to reduce the consumption of input gas to a minimum, it would probably be advisable to install a small separator at each well to receive the flow.

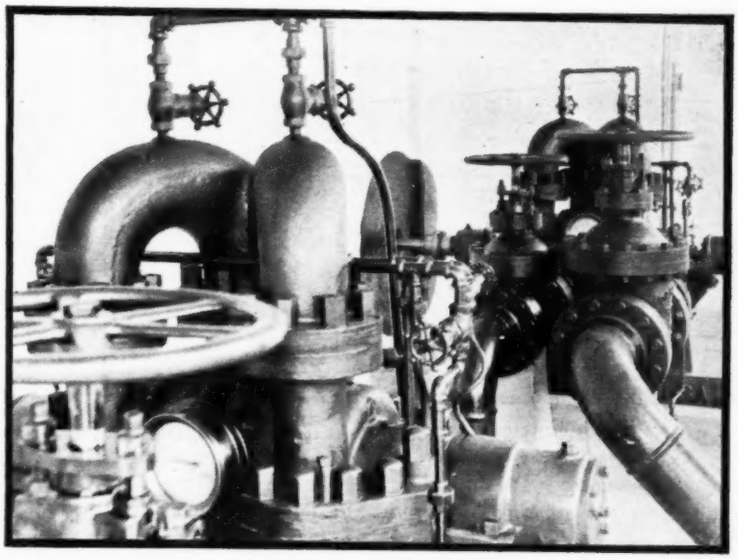
TABLE II

Data on Intermittent Flow with Chamber at the Bottom of the Tubing

Well	Tubing Diam.		Tubing Length	Chamber		Bbl. per Day	Time Interval			Working Pressure lb. per sq. in.	Cu. Ft. per Bbl.
	Outer	Inner		Diam.	Length *		On	Off	Total		
A	2"	1"	2900 ft.	4"	20 ft.	6	4	36	40	290	4500
B	2"	1"	2900 ft.	4"	27 ft.	12	7½	34	41½	290	3300
C	2"	1"	2900 ft.	4"	30 ft.	14	8	37	45	290	3300
D	2"	1"	3400 ft.	4"	22 ft.	22½	6	12	18	270	4200
E	2"	1"	3400 ft.	4"	32 ft.	22	7	19	26	270	4200
F	3"	1½"	4050 ft.	5 3/16"	66 ft.	135	....	....	15	325	2500
G	3"	1½"	4210 ft.	5 3/16"	50 ft.	100	7	8	15	325	2500
H	3"	1½"	4200 ft.	5 3/16"	46 ft.	45	....	....	30	225	3000
I	2½"	1½"	4240 ft.	5 3/16"	46 ft.	30	7	9	16	320	2000
J	4"	2"	4180 ft.	5 3/16"	45 ft.	83	....	....	18	250	3500

Atlantic Operating First Electric Generating Type Pipe Line Station

By LESTER M. GOLDSMITH
Vice-President, Atlantic Pipe Line Company, Philadelphia



A view of the pumproom. These two pumps have a rating of 29,500 bbl. daily

Diesel Engines Direct Connected to Electric Generators for Generating Power to Drive Pumps at Zavalla Station

THE Atlantic Pipe Line Company has introduced a new type of operating principle for modern pipe line stations with the completion and commissioning of its Zavalla plant.

The Zavalla station is located 20 miles south of Lufkin, Angelina County, on the company's 10-in. line running from the East Texas field to deep-water shipping facilities at Atreco, their terminal near Port Arthur, on the Gulf of Mexico. It is some distance from any high-voltage transmission lines of utility systems.

The station proper, in addition to the usual auxiliary buildings, consists of two main structures, the larger of which is known as the generating plant, while the smaller building is the motor and pump house. This presents a contrasting picture with other present-day stations.

It is here that the first practical application of electrical generating units, direct driven by internal combustion prime movers, has been introduced to the pipe line industry.

The current thus generated supplies power to operate the centrifugal pipe-line pumps. In the studies preceding the station design, the size unit was very carefully worked out so that such units, in multiples of two, three or four, could be used in connection with other electrically-driven centirfugal pump stations of the company. It is their intention, by such standardization and consequent reduction in costs, to make similar installations in other parts of their pipe line system.

This standardization not only reduces operating and capital costs, but provides for marvelous flexibility in that no one pump is tied up to any specific prime mover. This permits running any number of pumping units at one time, or one pumping unit in combination with any one of the generating units.

There are also many advantages in this type of station from a standpoint of safety and fire protection, since the electrical generating station is completely isolated from the pump station and there is no possible way for any pipe-line oil to come in contact with the prime movers or electrical gear.

As each prime mover is connected to a 60-cycle, 2300-volt generator, it can be used for driving any type of motor-driven pump, regardless of its rated speed. At other stations the company operates 60-cycle, 2300-volt motor-driven pumps, some of which are rated at 3580 r.p.m. and others at 1750 r.p.m. These standardized generator units, therefore, can be used in conjunction with pumping units of any speed.

Description of Equipment

The equipment at Zavalla station is as follows:

There are two Ingersoll-Rand, Type "MG" 11¼-in. by 15-in. Diesel engines, developing 350 hp. each at 400 r.p.m.

Each engine is directly connected to a General Electric generator, Type ATI, 225-kw. at 0.9 power factor, having a General Electric exciter, Type MPL, 20-kw., overhung and connected to the shaft extension of the generator.

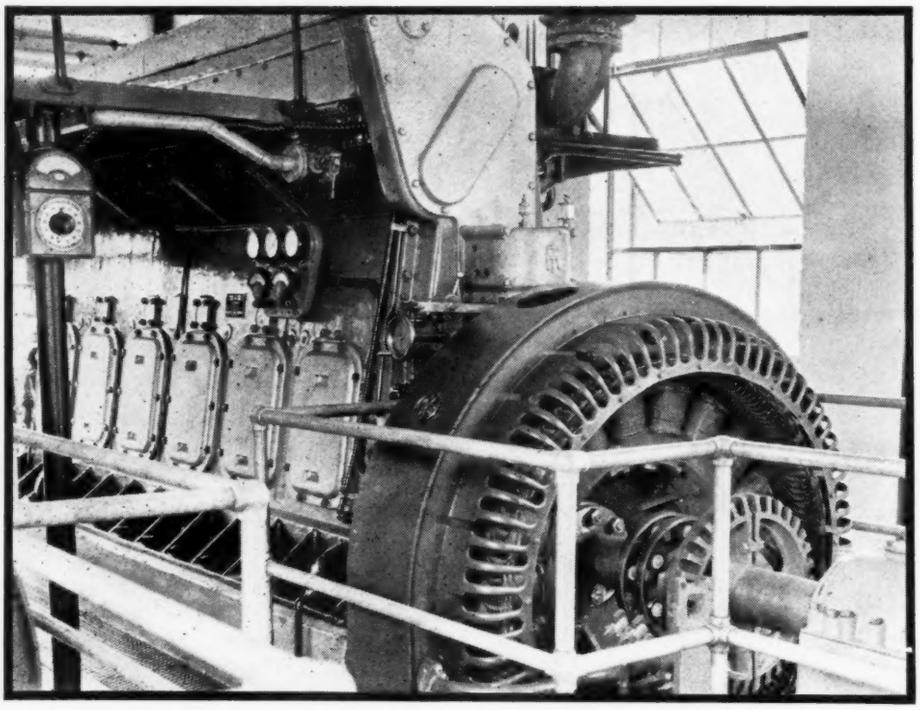
The circulating water is supplied by three Cameron motorpumps, each designed for 150 gal. per min. at 65-ft. head, one being for each engine, while a third is the standby unit for either engine.

The air compressor is an Ingersoll-Rand, Type 30, 2-stage, motor-driven, capable of supplying 250 lb. starting air.

The engine lubricating oil is purified by a Model 30-D Hydroil centrifuge.

Emergency lighting is provided for by a 5-kw. Kohler gasoline-engine-driven d.c. generator, which is also capable of supplying current for air compressor, water pumps and lubricating oil centrifuge when main units are off the line.

Adjacent to, but apart from, the generating station, as shown in photograph, is the pump station, which has a fire-



One of the two generating units at Zavalla Station. The Diesel engines are direct connected to the generator

wall completely isolating the motors and starting gear from the pumps. In this station there are two Byron Jackson pumps, rated at 29,500 bbl. per day, each direct connected to a 250-hp. General Electric motor, Type FT, 3-phase, 60-cycle, 2300-volt, operating at 3540 r.p.m.

The design of the operating equipment hook-up and control has been thoroughly engineered to obtain the desired power flexibility to make the station both practical and efficient. In the design an unusual condition was encountered, namely, the starting of a motor from a generator of practically the same size, the motor requiring approximately 350 per cent starting current. It was also necessary to design the station so it could be run by one operator, yet have the control fool-proof.

The control system permits the operator to use power combinations that will not only hold to a sufficient rated capacity but also protect the station from any troubles in the electrical power generating system that might cause a shut-down. This departure from pipe-line operating methods and precedents heretofore in use has an important bearing on the trend of future crude oil transportation systems.

Detailed Description of the Generating Plant

It was possible to eliminate the use of flywheels on the engine by the designing of a specially-built generator with sufficient WR^2. This reduced the length of the unit and also lessened the liability of torsional vibration in the crankshaft.

Another unusual feature is the fact that all engine-room auxiliaries are run from the exciters on direct current. The designers believe this to be a distinct advantage, as it makes possible the immediate starting of all the auxiliary machinery, including the water circulating pump, as soon as the engine is up to speed. This would not be possible if they were on the alternating-current side of the generator. It also means that in case of trouble where the master oil circuit-breakers drop out, killing the a-c. voltage in the plant, the lighting circuits are not affected.

In the general operation of the station, both engines are synchronized and the generators attached thereto feed into a common circuit from which both pumps are operated. This is the procedure when both pumps are in operation. When one pump is operated, however, it is necessary to operate only one engine and generator and herein lies one of the major problems in starting. When only one engine and generator is operating and it is desired to start one pump, the compensating starter on the motor for the pump is not used and the reasons for this are as follows: If the compensator were used as soon as the starter was put on the low-voltage side, the load would cause an immediate reduction in voltage on the generator, thus further reducing the voltage to the pump motor and there would not be sufficient starting torque available to turn the motor. By a cleverly arranged interlock between the two motor starters, when one compensating starter lever is locked out so it cannot be used, it is possible to use the other one for the following reason: It has been pointed out that when one pump is started from one generator, it is impossible to use the starter. However, when the condition is reached where one pump is running and the second engine is synchronized with the first, it is impossible to start the second pump across the line without the starter and, in such case, the compensator is used. By the interlock mentioned above, the operation is rendered fool-proof and no trouble whatever is encountered in the operation, it being impossible for the operator to make a mistake.

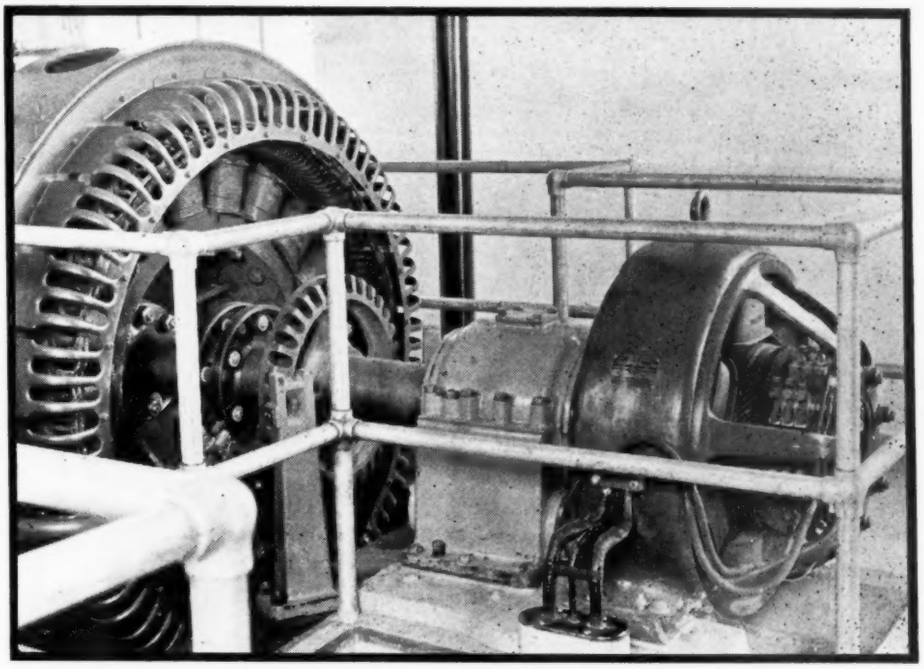
The engines are synchronized in the usual way, by means of a synchroscope on the switchboard.

It is interesting to note that a special governor arrangement was worked out for these engines, giving a maximum variation in speed of three per cent, and it is possible, therefore, easily to synchronize the engine without the use of motor-driven controls on the governor. To accomplish this, an original device was invented that may be of much interest to the readers and will be described below:

Any internal combustion engine has a definite "no-load" and "full-load" speed. Therefore, if one engine is running up to load and it is desired to synchronize the second engine with it, having no load, it is obvious that the oncoming engine must be brought down to the full-load speed of the engine on the line. It has been the practice heretofore to juggle one engine with the other until this point is reached and it is here that this novel device comes into play. A Veeder Counter was geared to the governor control shaft of each engine and set at

zero for the no-load speed. Observations were then made to determine the reading for full load. It is seen, therefore, that the number for the proper governor setting of the engine at full load is known and, in order to synchronize, it is merely necessary to get the proper number on each Veedor Counter and the engines are then running at the same speed. As soon as the Veeder Control of each engine records the same number, the engines are perfectly synchronized and will automatically divide the load equally. This device removes all personal error and even the most inexperienced operator can synchronize the engines.

Each exciter in this station is large enough to carry the excitation of both generators and the auxiliary load, so that at all times one is available in case of trouble. In actual operation, however, and in order to divide the load on the engines when both are running, excitation is carried on one and the auxiliary load on the other. By an arrangement of switching on the switchboard, neither of these exciters can be paralleled nor can they be paralleled with the Kohler auxiliary set, thus obviating any danger of motoring an exciter or generator.



The exciters are overhung and connected to the shaft extension of the generator

Prime Mover Cooling and Fuel Systems

The cooling system for these Diesel engines consists of two Griscom-Russell heat exchangers located on the suction side of the station. These are designed in such fashion so that to vary the temperature of the water going through the engines, the amount of water going through the cooler is varied rather than the amount of water. The purpose of this arrangement was to keep the quantity of water circulated through the engine constant and thus assure an efficient cooling system. Probably a great deal of the trouble that has been experienced in the past in many Diesel stations is due to scale forming as a result of a reduced quantity of water being circulated, thus causing local high temperature in the head. This high temperature of the circulating water in the head produces scale formation with the usually well-known result.

These coolers are arranged above ground and so piped that the tube bundle can be pulled for cleaning, without the removal or changing of any piping.

The fuel system is composed of fuel-oil storage tanks, day or feed tanks and a means for flushing the line. All the fuel requirements are met by taking crude directly from the main transportation line.

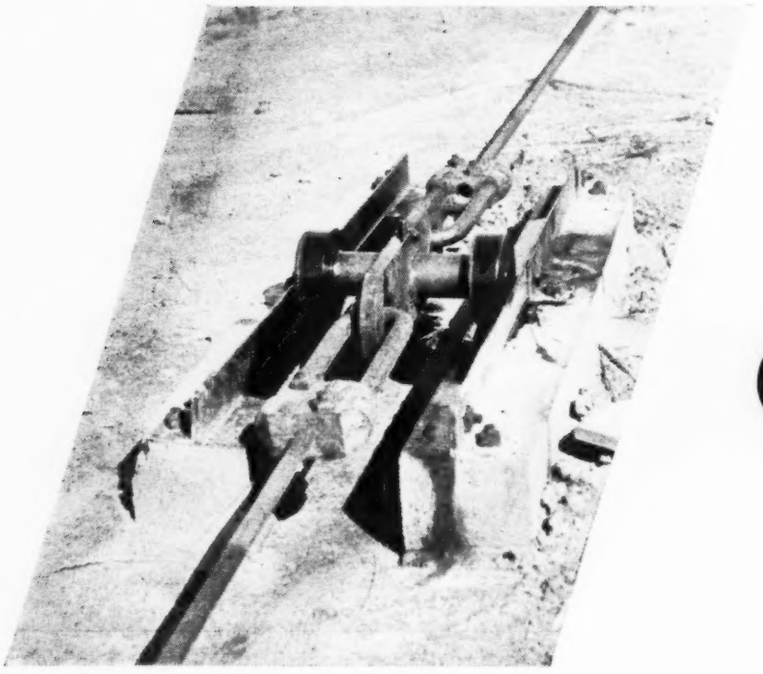
Each main fuel or storage tank has a capacity of 20 bbl. and is built on an individual tower 20 ft. high. The fuel is received into these tanks directly from the main line through a pipe connection of small diameter and through a cleverly devised vaporizer in the head of the tanks. The purpose of this vaporizer is to liberate the first wild gases and thus stabilize the fuel. These tanks are filled once every 24 hours, the oil being allowed to settle 24 hours before use and any resulting sediment in the bottom of the tanks is bled off into the station sump pit.

There are two small day tanks inside the station building that are filled by the operators as required. These tanks are hung from the walls of the building at such height that the fuel oil gravitates from storage tanks to the day tanks and from the latter containers to the engine.

If the engines are shut down and any crude oil is allowed to remain in the fuel pipes and lines, it congeals, making it almost impossible to start the engines after they have been idle for any length of time. It is, therefore, the practice to flush the system carefully with kerosene before the engines are shut down. For this purpose a small kerosene tank, connected to the fuel storage line and also to each engine, was provided. The entire fuel system is drained by lines to the pump pit, in order that any portion of the system may be emptied.

Another departure from pipe line practice that may be well worth mentioning is the materials of construction in both the generating station and the pipe-line station. The buildings are all of concrete with concrete roofs, using steel window-frames and are entirely of fire-proof construction, as the Atlantic Pipe Line Company believes that, since it uses the best equipment it is possible to obtain, it is only proper to use the best building materials.

It is most impressive to the visitor to observe the extreme simplicity of this installation and we believe it is only a matter of time when these basic principles will be widely in practice.



A hold-up of the roller type on a lease in the East Texas field equipped with geared central power.

Improved M
Of Installing C

By

K. C. SCLATER

DURING the last two years many modern central powers have been installed in Mid-Continent and Texas fields. Low crude prices and prorated production have created an increased demand for this class of equipment. Manufacturers appear to have anticipated this demand and have met it by putting out new units that embody up-to-date engineering features that are conducive to low operating and maintenance costs. Many of these powers are a radical departure in design from previous models and are of the geared type. Compact and sturdy, they are well adapted for oil-field service.

Several powers are installed in the East Texas field in areas where it is unlikely there will be any serious trouble from water encroachment. More engineering is put into the methods of installing powers than formerly. When groups of wells are to be pumped from a central power, it is now customary to test each well to determine its load and its pumping characteristics. From this information are determined the best pumping speed and the type of power most suitable.

Having the number of wells, their loads and pumping characteristics, their relative location with respect to each other, and a knowledge of the topography of the lease, the site for the power is chosen with some degree of care in order to obtain the most economical installation.

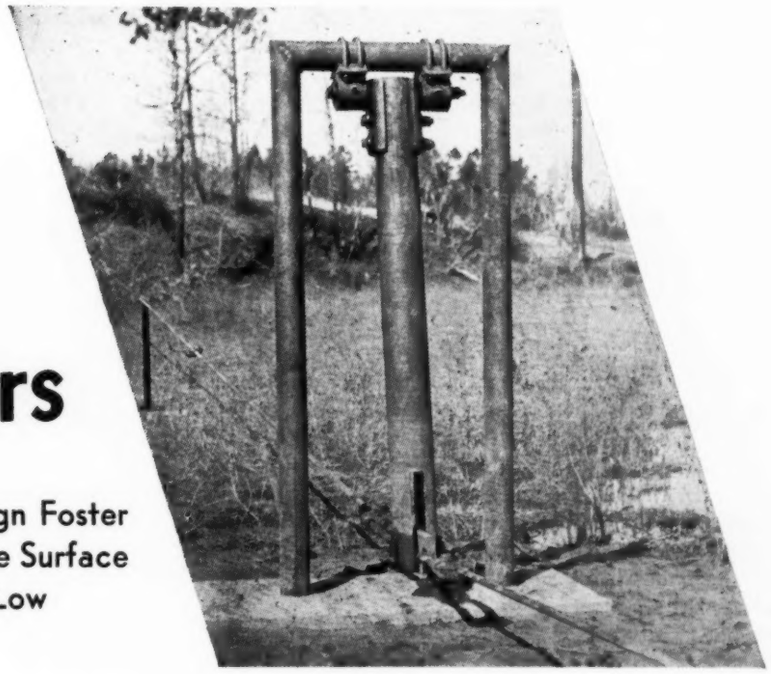
All modern power installations today are of all-steel construction. Especial attention is given to the proper installation of the shackle-line equipment, which can be a chronic source of trouble and of power losses. Shackle-lines are so laid out that they are kept in proper tension and thus reduce lost motion while in operation. On long spans sometimes the catenary curves of the pull rods are determined in order to accomplish this.

Several powers have recently been installed in the East Texas field and in the Panhandle field of Texas that are model installations of their kind. As much care has been taken in the layout of the shackle-line equipment as in setting up the power itself.

On the Sun Company's Till lease in the Carlisle district of the East Texas field a geared power has been in operation for some months. This was the first of five central pumping powers this company now has in this field. At this writing five wells are connected to the power. The shackle-lines range in length from 400 to about 2000 ft. and consist of 7/8-in. A.P.I. upset pull rods with forged steel clamps. All friction posts or shackle-line supports are set in concrete, about 2 cu. yd. per post, as also are the posts for the hold-ups, hold-downs and swings, which are all of the heavy duty type. For the knock-off posts about 1¾ cu. yd. gravel, ¾ cu. yd. rock and 8 sacks cement were used to set them in concrete. The average labor charge per knock-off post was about $5.00.

This installation has a knock-off post arrangement that is somewhat out of the ordinary. The power clevises that attach to the eccentrics have been cast and tapped for a female 2-in. pipe connection, 2-in. 6.40-lb. seamless tubing being used from the power to the knock-off posts. The end of the pipe near the knock-off post has a bail, which engages and disengages a 1-in by 6-in. steel slide bar that slides back and forth through a slot in the knock-off post. These knock-off posts are made from a 6-ft. length of 8⅝-in. O.D. casing into the upper end of which is inserted a hardwood plug 48 in. long. Both the plug and casing have a longitudinal slot through which the slide bar works. The slide bar is about 9 ft. long and has four 1½-in. notches about 20 in. apart cut in its lower edge. The bail that engages the slide bar is welded on the end of the 2-in. tubing 30-in. long and made from round 1½-in. stock. In operation the U-stirrup, which is attached to the knock-off post, acts as a throw-off hook. The end of the slide bar next to the power disengages, letting the 2-in. pipe connection drop down. When disengaged the rod slides back and forth on a strap with a pipe roller. This arrangement is quite simple and very safe for hooking the wells on and off. It was made after the Sun Oil Company's own design by the Beaumont Iron Works. Of the five wells now operating on the power, two belong to other companies and are supplied with power at a fixed charge per month. Five more wells of the Sun Oil Company will eventually be hooked up to the power, making ten wells in all.

The power itself is an Oilwell Imperial No. 80 oilbath geared power with 36-in. double eccentrics and is one of the first of this type to go into service. It is driven by a 125-hp. Waukesha WK model engine by means of a Dayton cog-belt drive from the power take-off of the engine to the extended shaft of the power. This extended shaft is 20-ft. long by 3 7/16-in. diam. and is floating in three Dodge Timken self-aligning roller bearings of the dust-proof, abrasive type. It is



A 2-post all-steel pendulum on a Sun Oil Company's lease in the East Texas field. It serves as either a hold-up or a hold-down, or both

Methods Central Powers

Geared Powers of Advanced Design Foster More Careful Alignment of Rod-Line Surface Equipment so as to Maintain Low Operating Costs

connected to the power shaft with a Fast flexible coupling. A 24-in. diam. 12-groove pulley is mounted on the drive shaft and an 11.8-in. diam. pulley on the engine. Operating at 16 s.p.m. the power has a total reduction of 27.7 to 1.

This power has several features that are worthy of note. It is a compact, fully enclosed weather-proof unit with gears operating in a bath of oil and requires no protection from the elements. Only a short V-belt drive is needed, which facilitates installation. Being driven by an extended drive shaft it has only a slight blind angle, thus requiring fewer swings and making it easier to obtain a better balancing of the wells.

A stationary spindle that is an integral part of the base is used with this double eccentric overpull type of geared power. Ample lubrication is assured all moving parts by a Nathan lubricator with six feed lines through which 30 gallons per 24 hr. is pumped, against a working pressure of 1000 lb. per sq. in. if necessary.

All eccentric strap bolts are steel-bushed and can be easily renewed and the clevises each has a 2-in. diam. steel pin that is Alemite lubricated.

Underpull pumping jacks are used at the wells and have a 52-in. mule-head stroke attachment. The wells are tubed to 2500 ft., where the pump is set, and are equipped with 2-in. plunger pumps and $\frac{5}{8}$-in. sucker rods. Of the other two wells not belonging to the Sun Oil Company, one is equipped with $2\frac{1}{2}$-in. tubing, a $2\frac{1}{2}$-in. pump, which is set at the bottom of the hole, and $\frac{3}{4}$-in. sucker rods. The remaining well has 2-in. tubing and an insert type pump with $\frac{3}{4}$-in. sucker rods.

Besides this power, the Sun Oil Company has four more installed on their leases in the East Texas field. They are all geared powers and are driven by 125-hp. Waukesha engines, except one, which is driven by a 80-hp. Franklin engine. One of these powers is a small Lufkin unit. The surface equipment in each installation is somewhat similar to that just described, except that the 1-in. pull rods of the upset type are used. In each case only the engine is housed, the geared power being securely set on a concrete foundation in the open.

On the Mid-Kansas M. A. Prince lease, right in the town of Carlisle in the East Texas field, a National G-100 geared power was very recently installed. It is the first of this type of power to go into service and is designed for moderately high pumping speeds and has a 100-hp. rating. This power is of the double-crank overpull type and is set on a concrete foundation in a concrete pit about 26 in. deep. It is set so low that the pull rods leaving the power are only 8 in. off the ground. The poor sandy-soil conditions necessitated the use of about 40 per cent more concrete than ordinarily would be required. In this instance the amount of concrete used for the power proper was about 65 cu. yards.

The lower crank has a 36-in. throw and positions for 12 wells, and the upper crank a 30-in. throw and positions for eight wells. The power is driven by a twin Superior 2-cycle engine through a drive shaft 3 15/16 in. in diam. and 30 ft. long. By using the 30-ft. shaft the blind angle is held to a small amount. There is a V-belt drive between the shaft and the engine.

All-steel shackle-line equipment is used on this installation and the longest shackle-line is 2100 ft. in length. All posts are set in approximately $1\frac{3}{4}$ cu. yd. concrete. Great care was taken on this job to get every piece of equipment in perfect alignment. National D-130 jacks are being used at the wells and these are also set in concrete, about $3\frac{1}{2}$ cu. yd. per jack being used because of the poor sandy-soil. The jacks have a rated polished-rod load of 13,000 lb. and a rated stroke of 48 in., which might be lengthened by paying proper attention to expansion and contraction in rod lines. An interesting feature of this installation is the use of the new Ideal safety throw-off. Though this is the first of this type of safety throw-off hook to be used in either Texas or the Mid-Continent, it has been in successful use in California for some time. It is a desirable piece of equipment, as it provides a safe method of hooking wells on or off the power. One is installed on each shackle line. On level ground it does away with the necessity of installing a swing post near the well.

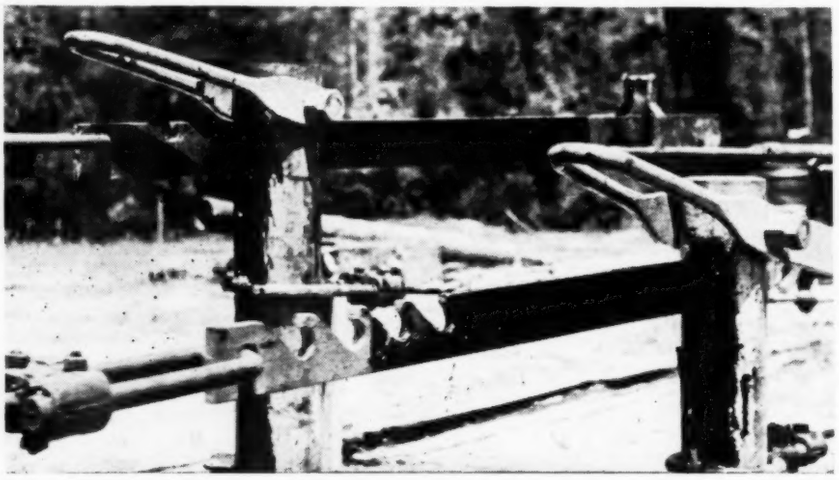
Another of the most recent central powers of the geared type to be installed in the East Texas field is that on the Stanolind Oil and Gas Company's Schuyler "B" lease. Six wells are at present to be pumped from this power and later others will be added. The power is an Emsco-Falk 36-in. stroke, single-crank overpull unit driven through a 40-ft. drive-shaft extension by a 150-hp. twin Bessemer gas engine. The

drive shaft runs in self-aligning Timken-bearing pillow blocks with adjustable sole plates. A V-belt power transmission between the drive shaft and the engine consists of a Timken-mounted V-belt clutch sleeve on the power drive shaft, a solid V-belt-driven sheave keyed to a jack-shaft that runs on two bearings and is connected to the engine shaft through a Falk flexible coupling, and a grooved idler with Timken bearings.

This power, like the other geared powers already described, is entirely enclosed in a grey iron housing, which has a heavy metal section and unusually heavy ribs, both in the upper and lower half. Even the oil-pan is ribbed to anchor it securely to the concrete. The cover is held to the base by body-fitted bolts in reamed holes, thus removing any possibility of slippage between the top and bottom halves of the casing.

In the bottom of the gear case the capacity of the reservoir for lubricating oil is 70 gallons. A special reversing Perfection oil pump with by-pass valve is mounted on the cover and is driven through a set of speed-increasing gears from the intermediate shaft, providing a sufficient volume of lubricant even when the wells are pumped at a speed of only 6 s.p.m., yet producing no excessive pressure should the wells be pumped at 30 s.p.m. Change of weather or variation in the viscosity of the lubricant cannot impair the lubricating system.

Shackle-line equipment including knock-off blocks, combination clamps and turnbuckles, are all products of the American Manufacturing Company. The size and make of pull rods are 1-in. A.P.I., D & B. An interesting feature of the surface equipment is that it includes American Taylor roller rod-line carrier blocks, which have a bronze-bushed Alemite lubricated sleeve to reduce friction. These are set on 2½-in. pipe posts.



Knock-off posts on the Sun Oil Company's Grey lease, East Texas field. On this installation the notches are on the upper edge of the slide bar

Five of the wells are equipped with American 7-5-A jacks and one with a Jensen 45 jack. Concrete foundations are used throughout, for prime mover, power and jacks, also all posts are set in concrete.

One of the model central power installations in the Texas Panhandle fields is to be found on the Skelly Oil Company's East Schafer lease about seven miles from Pampa. This is a National 15-C band-wheel power. Although the power is not at present fully loaded its ultimate capacity is 16 wells, which on this lease average 3200 ft. in depth.

This is an underpull power and is driven by a 24-in. belt through a countershaft to a 100-hp. twin Superior 2-cycle gas engine. It is equipped with an automatic floating idler to compensate for changes in humidity and in load conditions.

When a well is completed that has to be put on the power it is customary on this lease to pump with a portable individual pumping unit mounted on skids until such time as the well is ready to be placed on the power. It is driven by a 25-hp. Waukesha engine and tests are made on the well for load and pumping characteristics preparatory to placing it on the power.

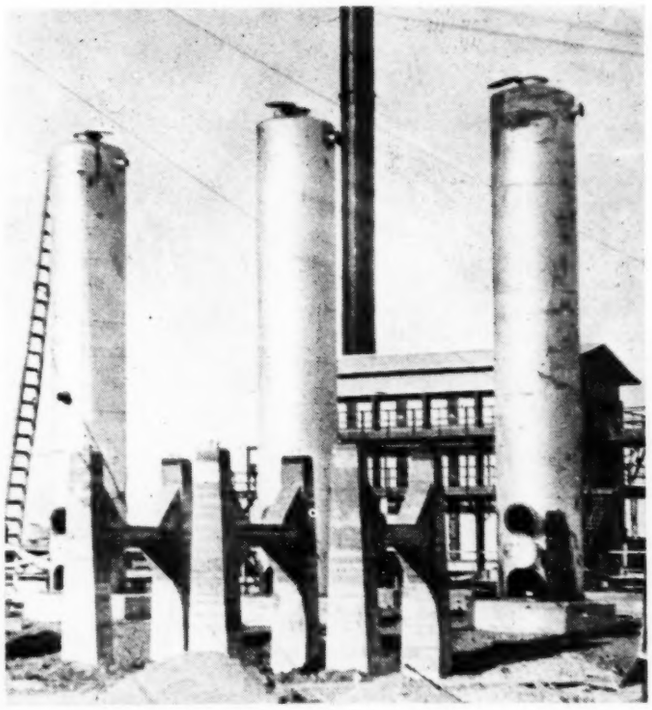
Before the installation of this power the surface conditions were given thorough study in order to determine the most suitable layout for the surface equipment. Shackle-lines were lined up carefully with surveying instruments and allowance made for the sag in pull rods between posts. All posts are set in concrete. Where small sharp depressions are encountered at the surface, long friction posts or shackle-line supports, some more than 20 ft. high, are used to carry the rod line straight across with little or no change in elevation. In this way rod-line friction losses are kept as low as possible.

On this lease the pumps are set close to bottom and common working barrels and 2½-in. external upset tubing are used.

There are in all in the East Texas field more than a dozen powers already installed. As already stated these are being put on leases in areas where it is expected there will not be any serious trouble from water encroachment, or in areas where the wells are not likely to produce large quantities of fluid. On the east edge of the field, where the producing horizon thins out to a feather edge, many of the wells when they reach the pumping stage will be small enough and sufficiently free from water that they will be particularly adaptable to pumping from central powers. Another factor that favors the installation of central powers is the topography. It is not too rugged. In low-lying places where flood conditions are likely to be encountered a properly installed central power is feasible for economical and continuous pumping. These are some of the reasons for the great interest in central powers in the East Texas field.

In every power that is now being installed more than ordinary care is taken to see that everything is in proper alignment and is so laid out that it will be easy to maintain in alignment. Foundations are made heavy enough to prevent settling. This is an important consideration in most parts of the East Texas field because of the poor sandy-soil conditions that obtain there. Settling causes misalignment, which usually becomes a serious source of power loss. Loose shackle-line equipment also transmits shock and stresses to the pumping equipment in the well that may result in much unnecessary rod trouble and expensive pulling jobs. A properly installed central power and surface equipment properly laid out pays for itself in a low unit lifting cost, which is the chief consideration in all producing operations.

New Globe Plant Embodies Latest Processes and Equipment



Foundations for treating plant in foreground with stripping towers and furnace in the background

First Installation of Lachman Process in Mid-Continent

By F. R. STALEY

OPERATIONS will be started in the new plant of the Globe Oil and Refining Company at McPherson, Kan., the latter part of this month. This refinery, designed by the Winkler Koch Engineering Company, to process 8000 bbl. of McPherson County crude daily, embodies some of the most recent developments in refinery engineering.

By a combined topping, cracking and reforming operation, carried on in two furnaces, a yield greater than 70 per cent of 70-octane gasoline will be obtained. The cracked gasoline will be treated in the vapor phase by the Lachman Process, using a concentrated solution of zinc chloride. This is the first installation of the Lachman process in the Mid-Continent area.

The crude oil will be debutanized before it is charged to the distillation unit and after passing through heat exchangers against the vapor from the Lachman tower and from the cracking tower, the crude enters a settling tower, where water is settled out. It then enters the debutanizer tower, which is 5 ft. in diameter and 54 ft. high, operated under 50-lb. pressure. The crude is next charged to the pipe still and then flashed into a tower 9 ft. in diameter and approximately 94 ft. high. There are also three stripping towers each 4 ft. in diameter and 18 ft. 6 in. in height.

Two units are installed to stabilize the gasoline. The pressure-distillate stabilizing tower is 5 ft. in diameter and 56 ft. high, and the light-gasoline stabilizer, 4 ft. in diameter and 80 ft. high. The cracked vapors from the Lachman treater enter the stabilizer after passing through heat exchangers and a steam pre-heater. The overhead from this tower enters a gas separator, from which the tower reflux is drawn. The fixed gas, together with the gases from the cracking process and from the crude debutanizer, enters a gas receiver, from which the compressors take suction. This installation consists of three Clark 2-stage compressors for 325-lb. working pressure. The gas from the first stage passes through water coolers into a separator, from which the second stage takes suction and discharges into the light-gasoline stabilizer, which contains 30 bubble trays. The residue gas from this unit is used as refinery fuel.

Vapors from the cracking-still bubble tower enter the bottom of the Lachman contact tower, which is 8 ft. in diameter and 58 ft. high. It is lined with copper sheet ⅛ in. thick and contains 14 cast-brass bubble trays. A concentrated solution of zinc chloride is pumped into the tower over the third tray, superheated steam being used to control the concentration of the solution. The layer of froth on each deck is about 15 in. thick. About 0.005 per cent of polymers is formed.

The vapors from the top of the contact tower enter the bottom of a lime-rock tower 8 ft. in diameter and 30 ft. high, and lined with vitrified brick. It is filled with lumps of lime stone from 4 in. to 12 in. in diameter. The purpose of this tower is to remove hydrogen chloride from the vapors. Calcium chloride is formed in the tower, from which it is drawn off as brine. This automatically exposes a fresh surface at all times to the vapors. A change of lime lasts about 120 days.

From the lime tower the vapors next enter a final bubble tower 9 ft. in diameter and 42 ft. high and containing cast-iron bubble trays. The condensers are cast-iron pipe coils. Ammonia gas is injected into the vapor line to remove the last traces of hydrogen chloride. The streams from the condensers flow into gas separators. Facilities are provided to bypass the Lachman plant in case of emergency.

The zinc chloride is received at the refinery in 50 per cent solution. In use, zinc sulphide and oxychloride are formed. The amount of solution fed varies from 1 lb. to 10 lb. per bbl. of distillate being treated. The solution is in equilibrium with its vapor so that the concentration will depend upon the pressure and temperature. For the use of the Lachman Process the royalty is 4 cents per 42-gal. bbl. of finished gasoline. The operating cost is about 2 cents per bbl.

The treating plant is designed to handle the straight-run and the cracked gasoline separately, for which purpose duplicate equipment is installed. Doctor solution or lime solution can be used in the plant. Contact is made by pumping the gasoline and the solution through Duriron mixing nozzles, after which the solution is then settled out in two horizontal tanks in series. Sulphur solution is added at the mixing noz-

zles. After leaving the second settling tank the gasoline is washed with water in a mixing nozzle. It is then allowed to settle in a third horizontal tank. Chapman lubricated plug valves are used extensively in the treating plant. Two 500-bbl. agitators are installed for treating the kerosene or special naphtha made in the refinery.

A Foster Wheeler superheater of 250-lb. operating pressure is installed for heating the steam used in the Lachman tower. Steam is generated by two 500-hp. Heine boilers, which can be operated at 300 per cent overload. Water for the refinery will be obtained from a well by means of a 40-hp. motor-driven Layne Western pump. A 600-gal.-per-min. Prichard cooling tower is installed in the plant. All the water will be treated by the Graver hot process, as a result of which the treated water will contain less than six grains of total solids per gallon.

Two Worthington crank-and-fly-wheel cross-compound condensing hot-oil pumps will be used to handle the hot oil. National steam pumps are installed to handle the oil and distillate in the plant.

The plant will be largely automatic in operation. Recording and control instruments are installed on almost all units. Brown pyrometers will be used for controlling furnace and transfer temperatures and Neilan instruments for controlling the operation of the stabilizers. Liquid levels will be maintained by Fisher level controls. The pumps and compressors are equipped with McCord lubricators.

A vacuum flash still is installed to reduce the cracked residuum to pitch.

A 2-story brick building houses the offices and the testing laboratory. It contains four private offices. The knock testing engine is installed in a small 10-ft. by 10-ft. building. One long metal building will contain the machine and pipe shops, also the air compressor and the locker and wash-rooms for the employees.

Graver riveted tanks are installed for storage. Two 55,000-bbl. tanks are provided for crude oil and another for fuel oil. There are two 25,000-bbl. tanks for gasoline and a third for fuel oil. In addition there are eight more 10,000-bbl. tanks for gasoline, and twelve 2500-bbl. run-down tanks. Natural gasoline for blending will be stored in 10 horizontal tanks, each 8 ft. by 38 ft.

A 60-car loading rack is provided for loading tank cars. Facilities are provided for unloading casinghead gasoline and zinc-chloride solution, which is received in tank cars.

The plant is illuminated at night by means of a flood-lighting system. The conduit is run under the ground. A 7-ft. 8-gauge wire fence surrounds the entire property.

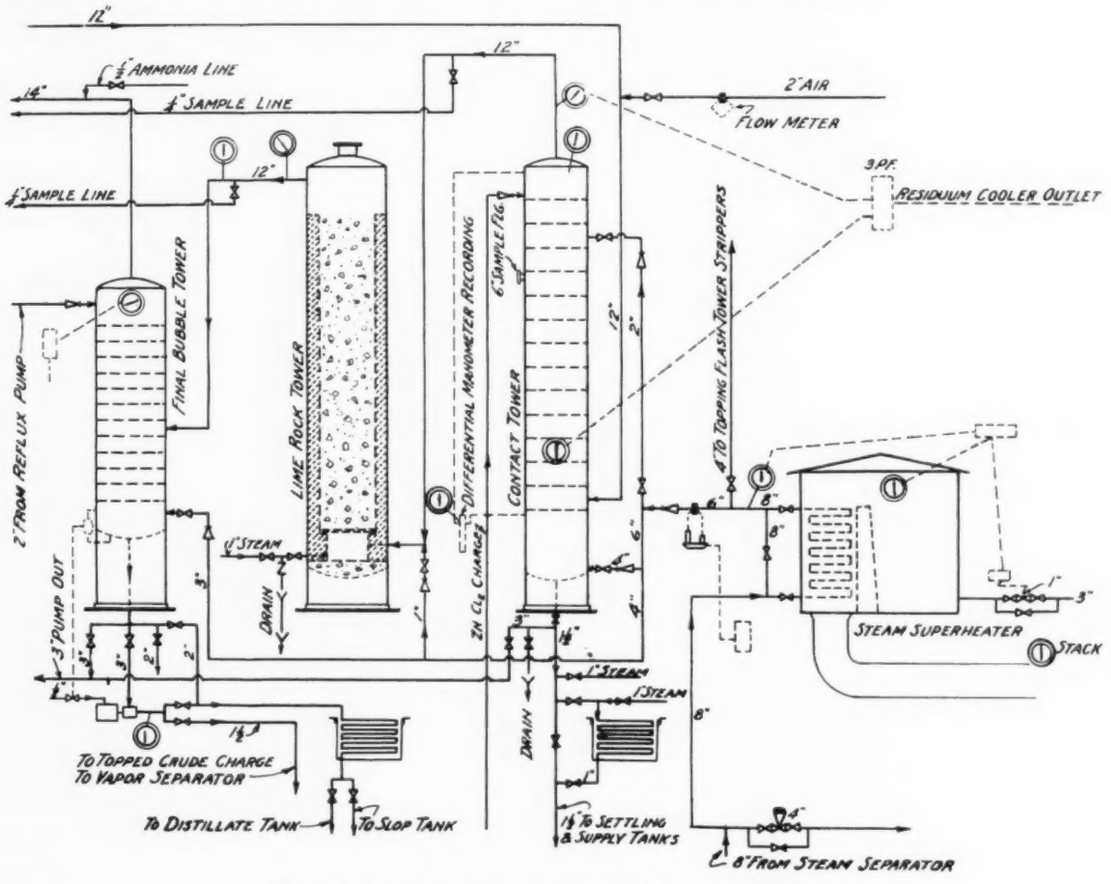
The company plans to lay a gasoline pipe line from the plant to Superior, Neb., a distance of about 140 miles.

Lachman has discussed the results of treatment with zinc chloride. Refinery losses are extremely small, not exceeding 0.5 per cent. Plant efficiency ranges from 98 to 99 per cent. The octane number of the gasoline is unchanged. The zinc-chloride treatment produces permanent color and gum stability.

Color instability is largely an oxidation process. Some of the absorbed oxygen appears as gum and some appears to be present in peroxide combination. The latter has a marked depressing effect on octane rating; and there is a danger of loss during storage. This loss is not observed in zinc-chloride processed gasolines.

Zinc-chloride treatment of cracked distillates has the further advantage in that a variety of stocks can be treated in practically the same manner and none will show signs of being overtreated.

This method of refining gasoline is a departure from previous practice. It combines the ability of sulphuric acid to treat all types of stocks, and enables the refiner to manufacture a cracked gasoline practically free from gums that will not go off-color in storage.



Flow Sheet of Lachman Treating Plant at McPherson

Migration and Encroachment of Water in the Bradford Sand

Study of Waters Produced with Oil Reveals Interesting Data on Movement of Connate Water

By PAUL D. TORREY

Torrey, Fralich & Simmons, Ltd., Geologists and Petroleum Engineers, Bradford, Pennsylvania

THE migration of water through the Bradford sand has been the subject of thorough study in connection with the flooding operations that are employed to increase oil recovery in northwestern Pennsylvania. The amount of oil that may be recovered by water-flooding is primarily dependent on the amount of oil left in the sand, but the efficiency of this recovery is directly related to the characteristics of the reservoir rock, which will determine the degree of uniformity of water migration through the sand body.

During the early period of water-flooding operations it was recognized that variable results were being obtained on different properties, even though the same method of development was in operation. Such variations could not be readily explained until cores were taken from the sand and analyzed. The results from the study of cores have been of tremendous importance, not only in determining the most advantageous method of flooding, but also as an accurate indicator of the amount of recoverable oil. Core analyses, however, possess little value unless they can be directly correlated with actual production statistics, and this is particularly true in a study of cores taken in partially or what is believed to be entirely watered-out territory.

The rate of water migration through the sand body is dependent upon the uniformity of the sand and the continuity of the individual beds, the porosity and saturation of the sand, the permeability of the sand, the distance between input and outlet wells, and the volume of water introduced into the sand at varying pressures.

The relation of the first two of these factors to the rate of migration should be quite obvious, particularly in thin-bedded sands. Where there are large variations in porosity, permeability and oil saturation in individual beds, there will unquestionably be variations in flooding action, and in consequence it is not uncommon to find the sand in cores taken in partially watered-out territory to be in all stages of depletion. That is, certain of the more permeable beds may be almost entirely saturated with water; the less permeable beds only partially saturated and the beds of low permeability containing little or no water. Irregularities in the continuity of the individual beds have a similar effect. In discontinuous beds, or beds that change in lithology between the intake wells and the producing wells, oil will be concentrated at the point where the bed lenses out or where the permeability decreases to the point where further migration is prevented at the existing pressure in the sand body.

The effective porosity of the sand, which may be defined as the percentage of connecting voids, determines the capacity of an individual volume of sand to hold gases or fluids. In consequence, the porosity of the sand and its thickness will be important factors in determining the amount of oil left in the sand under a unit area. The percentage of oil saturation in the sand has a very direct bearing upon the rapidity of water movement. This condition was soon recognized during the earlier period of water-flooding development for it was discovered that the water would migrate very rapidly in the gas pays found at the highest part of the structure. The normal rate of water movement between wells of constant distance in representative Bradford sand, having a thickness of 20 ft. and an average porosity of 12 per cent, with an average pressure of 1000 lb. per sq. in. at the top of the sand is shown in the following table:

	Average Oil Saturation					
	0%	10%	20%	30%	40%	50%
Rate of Migration per day—ft. -	20.0	7.2	3.8	1.7	0.8	0.4

Variations from these figures will naturally be found where the permeability is not constant. This same relation may be observed in laboratory experiments on the initial permeability of sands that have been artificially saturated with varying amounts of oil. The following figures are expressed according to the definition proposed by Barb[1] "as referring to the number of cubic centimeters of fluid which will pass per second through a length of sand of one centimeter, and with a face of one square centimeter, where the pressure drop is one gram per square centimeter."

*Approx. Oil Saturation**	*Permeability, cc.*
0%	2010 x 10^{-8}
10%	985 x 10^{-8}
20%	510 x 10^{-8}
30%	245 x 10^{-8}
40%	111 x 10^{-8}
50%	65 x 10^{-8}
60%	51 x 10^{-8}

The effect of permeability on water movement through the sand is clearly indicated in the graphical analyses of four cores shown in Fig. 1. Well No. 1 is a water intake well located 220 ft. away from the producing well (well No. 2). Twenty months after water had been turned into well No. 1, well No. 3, located 80 ft. from the intake well, was drilled and the sand cored, and 24 months after the water was turned in, well No. 4, located 50 ft. from the producing well, was drilled and cored. During this time water had been put into well No. 1 to the amount of 20,320 bbl. per acre and well No. 2 had produced during the same period 5885 bbl. oil and 6250 bbl. water per acre. The relationship between variations in the permeability of the sand and the amount of oil and water left in the sand is very striking and certainly indicates the necessity of accurate information regarding sand conditions in order effectively to control water migration. It was studies similar to this, based upon core analyses, that were responsible for the first delayed-drilling experiments. This system has been most successfully employed as a means for increasing the efficiency of water-flooding operations.

The distance between the input and the producing well naturally affects the rapidity of water migration through the

[1]Barb, Clark F., "Porosity-Permeability Relations in Appalachian Oil Sands," Pennsylvania State College, Mineral Industries Experiment Station.

*Standard sample of sand 11.2 per cent porosity.

sand, for as the distance is increased there is an increased frictional resistance to fluid movement. The most effective water pressure for any specific distance, therefore, cannot be determined unless the permeability of the sand is known.

The amount of water that can be put into the sand at a constant pressure through any one intake well decreases with the advance of the flood. The average daily water input in a representative intake well with 22 ft. of sand having an average porosity of 12.1 per cent is given below:

1st Quarter	120 bbl.	Avg. for 2nd Year	37.5 bbl.
2nd Quarter	105 bbl.	9th Quarter	22 bbl.
3rd Quarter	72 bbl.	10th Quarter	19 bbl.
4th Quarter	58 bbl.	11th Quarter	17 bbl.
Avg. for 1st Year	88.75 bbl.	12th Quarter	15 bbl.
5th Quarter	51 bbl.	Avg. for 3rd Year	18.25 bbl.
6th Quarter	42 bbl.	13th Quarter	14 bbl.
7th Quarter	30 bbl.	14th Quarter	13 bbl.
8th Quarter	27 bbl.		

The decline in input may be attributed to the gradual filling up by water of the sand pore spaces that are not saturated with oil. As the volume and weight of fluid in the sand increases more work must be done to maintain a uniform movement. This can be accomplished by increasing the pressure. A review of these factors that determine the rate of water migration through the sand in water-flooding operations would indicate that these same factors may influence and control the encroachment of connate waters into an oil field. A study of the waters produced along with the oil in flooding operations has revealed many interesting data on the migration and accumulation of oil and the encroachment of connate waters.

The water used in flooding operations is in general a very pure water in so far as dissolved mineral salts are concerned. This water moving through the sand dissolves salts precipitated in the pore spaces and comes into the oil well as a strong salt solution. It has been noted, however, that the initial flood waters coming into a well do not carry a constant volume of salts in solution and subsequent investigations have shown that the most dilute solutions are found on the highest part of the structure with a general increase in concentration going down the dip until at the approximate contact between the oil and connate waters the concentration of the initial flood waters is almost equal to the concentration of the connate water. It has also been discovered that the chemical composition of these waters changed from the top of the structure to the limits of the field, as follows:

Total dissolved salts in initial flood water. P.p.m. by weight	Top of Structure 18,900	400-ft. Contour 51,670	300-ft. Contour 83,100	200-ft. Contour 102,570	100-ft. Contour 126,200
Per Cent Composition					
$CaSO_4$	8.5%	3.1%	0.8%	0.3%	0 %
NaCl	83.5%	85.3%	85.1%	79.8%	64 %
$MgCl_2$	3.2%	3.8%	4.8%	5.1%	5.2%
$CaCl_2$	4.6%	7.5%	8.9%	14.1%	28.9%
KCl	0.2%	0.3%	0.4%	0.7%	1.9%

The concentration and the percentage composition are the average of 63 analyses taken from wells located approximately upon even 100-ft. contour lines. The elevation of the top of the structure is approximately 550 ft. above sea level, and the water-oil contact approximately follows the 100-ft. contour. It may be assumed from these figures that the water of sedimentation, derived from the sea at the same time the sand was being deposited, was gradually concentrated by the evaporative effect of migrating natural gas during the period of oil accumulation. As the structure was being filled an increasingly concentrated solution was being pushed down the flanks and following the solubility-product-constant principle $CaSO_4$ was precipitated in its largest percentage at the top of structure, NaCl in its largest percentage about half way down the flanks, and $MgCl_2$, $CaCl_2$ and KCl in their largest percentages near the oil-water contact.

The precipitation of such large volumes of mineral salts in the pore spaces of the sand in the lower part of the structure unquestionably must have reduced the permeability in a manner similar to that produced by secondary cementation by calcite or silica. The writer, therefore, believes that migration and accumulation ceased not because of a diminishing amount of oil and gas available but rather to a decrease in permeability, which effectively prevented any further movement under the natural pressures available.

Though more than 275,000,000 bbl. oil has been removed from the Bradford sand there has never been any serious water encroachment, despite the fact that the field is essentially limited by salt water under an almost natural hydrostatic head (650 lb.). Precipitation of salts in the sand has probably reduced the permeability so that natural hydrostatic pressure is now insufficient to cause movement of water, thus necessitating the application of artificial water pressure.

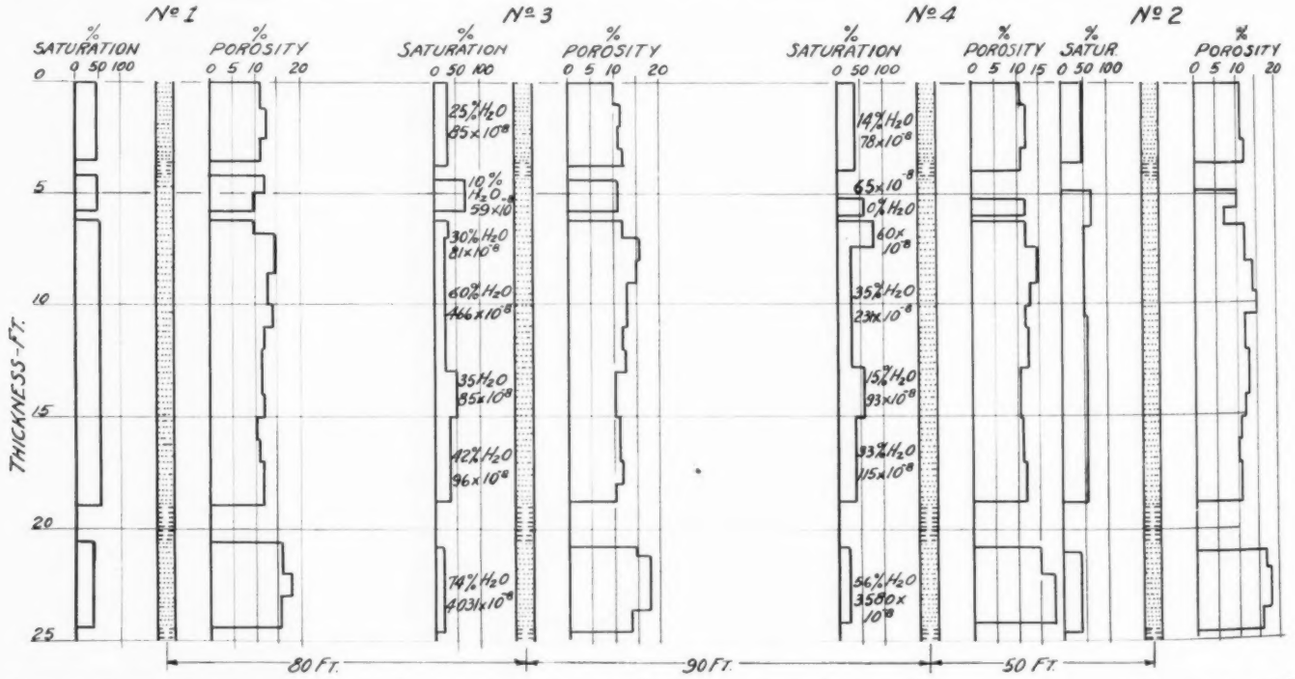


Figure 1. Graphical analyses of four cores from the Bradford sand, showing the effect of permeability on water movement through the sand

Methods of Cleaning a California Pipe Line

Southern California Gas Co. Line Reconditioned After 20 Years

Rapid Progress Made With Hand Labor and Machines

SOIL conditions, while frequently the cause of greatest deterioration, are not the sole agents of line pipe destruction. Internal corrosion often disintegrates the pipe and while the transportation of oil or gas with a high sulphur content may corrode the line generally, there may be isolated spots that alone need replacement. This is especially true of gas lines since water may collect in low places to corrode only that portion of line where moisture is trapped. Soil conditions, too, may vary greatly over the length of a line and act on the pipe in spots that may be great or small in extent. With a small percentage of the joints needing renewal, therefore, a reconditioning job will often put a line in almost perfect condition. It will generally cut down the constant repairs that become necessary when lines have been in service for a number of years and the new pipe required for the work will probably prove more economical and give better service than will the patching up of the few joints of old pipe that have become badly corroded.

12½-in. Southern California Gas Company line after being reconditioned

Reconditioning work, however, may require only the uncovering, cleaning and retreating of pipe without replacements. On some of the trunk oil lines in California such work has been done without cutting off the service. In practically every case of this kind the pipe has been lifted from the ditch in sections that were short enough to be taken care of adequately by the slack.

While pipe line coating is still being given considerable study, it is generally conceded that the proper treating of lines in "hot spots" has done much to add to their life. Different soil conditions have, naturally, had different reactions and in the lines recently taken up there have been obvious effects both of electrolysis and of chemical action. Many of these lines have been in the ground a long time, however, and some of the earlier coatings applied to the pipe could not be so effective as many that have recently been developed. No matter how good the coating is when the pipe is lifted out of the ground it must be thoroughly removed before the pipe is again treated.

The methods used for cleaning pipe vary with the organization doing the work. Considerable stress has been put on hand labor during the past year, while oscillating tools, wire brushes, scrapers and chipping hammers have been used extensively and sand blasting has maintained its favor with many companies.

A rotary pipe-cleaning machine has recently been introduced in California and used on some reconditioning work. This consists of a frame that is placed around the pipe and in this frame are revolved chains on which hard faced pointed studs are welded. The chains are driven through a belt by an electric motor mounted on top of the machine. The motor is supplied with current by a gasoline engine-driven generator set mounted in a trailer. The machine and motor are also placed in the trailer when not in use and the unit transported along the line to the place where the pipe is to be cleaned. For new pipe, the chains are replaced by steel wire brushes.

With most of the lines that have been reconditioned, any joints that had to be broken were remade with the same type. A vacuum line in the Kettleman Hills field having the welded bell and spigot type of joint with welding dam was reconditioned and many of its joints had to be broken. These were naturally merely cleaned thoroughly and re-welded.

An interesting reconditioning job, however, was that on a Southern California Gas Company line carrying gas from the Buena Vista Hills to Los Angeles, where a coupled line was transformed into a welded line.

The line was about 30 miles in length and consisted of 12½-in. diameter pipe that had been in almost constant service for 20 years. The reconditioned section lay in a desert area at the southern extremity of the San Joaquin Valley, where it was subject to mountain rains and hot winds that uncovered it for several hundred feet in some places, while depositing additional covering over it in others. Despite these severe conditions the couplings had given excellent service for, during the 20 years the line had been in operation, the coupling gaskets had been renewed only once, the coupling bolts tightened once and some 500 leaks repaired.

After being pulled up, the pipe was found to be in fairly good condition with certain sections showing greater deterioration than others. The weaker joints were replaced with new pipe of the same specification as the old. The external corrosion was not extensive and a small amount of internal

corrosion was found at low points where water had had a chance to collect. Some pitting showed up at the ends of the joints under the couplings.

The pipe was plain-end without bevel and in order to make a satisfactory and economical joint a chill ring was inserted at each weld. In this type of joint a welding dam extends along the center of the chill ring around its outer perimeter and, being but 1/16 in. high, does not protrude to the outer surface of the pipe when it is in place. On this job a square appearance was given to the top of the welding dam because it was ⅛ in. too high when received on the job and it was necessary to cut it down to the desired specifications. While the chill ring cuts down the inside diameter of the pipe at each joint for a fraction of an inch, its stream-line design was made to offset the restriction and it was felt that it would have little or no influence on the capacity of the line. The ring assisted, moreover, in stabbing the pipe and in keeping the joints properly spaced as well as functioning in the welding process. All welding was done by the electric arc method.

Although the reconditioning and reconstruction of this line was done mainly by hand labor, the work progressed at a rate of approximately 4000 ft. a day. Two tractors with side booms, together with the necessary trucks for hauling skids, materials, generators for welding, etc., were the only machines used besides the backfillers and ditchers.

The cleaning of the pipe was done at night by two crews of 26 men each with their shifts running from 5 p. m. to 1 a. m., and from 1 a. m. to 9 a. m. The work being done during the past summer, the heat encountered during the day made this night work necessary, since it made what was left of the original pipe coating so soft that it gummed up the tools and prevented the effective cleaning of the pipe.

The ditching machine first uncovered the pipe to within an inch or two above its top. A spotter crew then followed this machine and completed the excavation to a point just below the surface of the line. This crew also excavated holes around the line every 30 to 40 ft. and thus provided a place for the tongs to grab the pipe when lifting it out of the trench. In raising the pipe it would tend to bend at the couplings, so care had to be taken to keep the ends from being damaged.

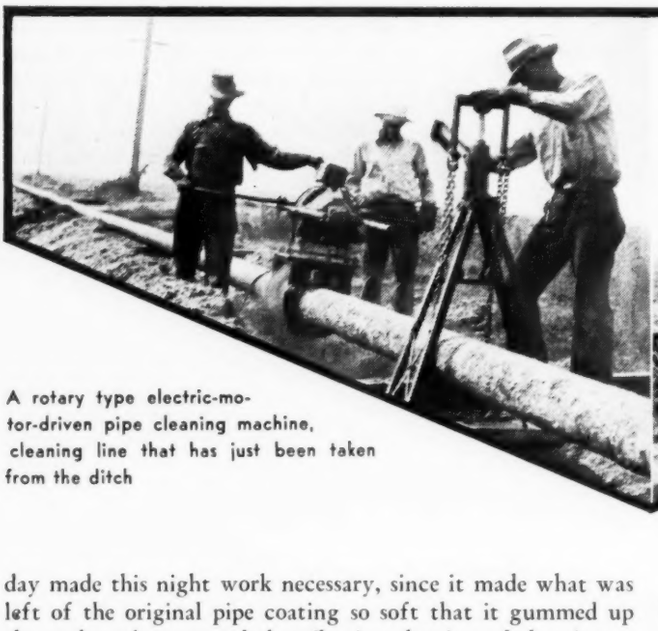
After the pipe was raised it was placed on skids and pulled back from the ditch for a distance of four or five feet. An acetylene torch was then used to cut through the gasket, center rings and followers of the coupling on one side. This was done in one operation, after which the couplings were driven off the pipe.

A careful inspection of both the inside and outside of the pipe was made as soon as the joints were broken and those lengths not in good condition were marked for replacement with new ones. In many sections there would be found continuous lengths that could be welded together again, while at other places there would be quite a few that had to be replaced. This condition was not due entirely to the action of the soil, for there were many cases where internal corrosion caused by water collecting in the line had weakened the walls of the pipe. The ends of all joints that could be used again were immediately filed and cleaned with a wire brush.

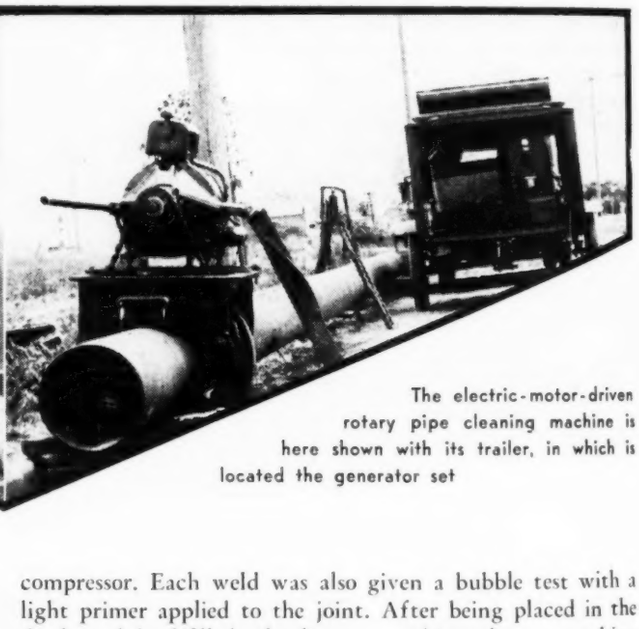
A line-up crew inserted the chill rings in the pipe after replacing the worn lengths with new ones. It also placed sections of the line on skids and dollies and tack-welded the joints. These sections, which ranged in length from 300 to 400 ft., were then welded by the firing line and the reconditioning work started. The pipe was first thoroughly cleaned and put in the best condition possible for the protective coating. A primer was then put on and this was followed by an application of the pipe coating.

A preliminary test was given to the line as soon as sections from one to two miles in length were made up and before it was lowered into the ditch. This test consisted of the application of a pressure of 100 lb. per sq. in. by a portable air compressor. Each weld was also given a bubble test with a light primer applied to the joint. After being placed in the ditch and backfilled, the line was subjected to a working pressure test of 400 lb. per sq. in. Valves and crossovers to an adjacent line were reconditioned or replaced as the final operation before the line was turned back to service.

Reconditioning of both oil and gas transmission systems is constantly becoming more important, due largely to the fact that many of the major lines have been in service for a great many years. Therefore, there is an ever increasing interest being shown in pipe reconditioning methods and indications are that the industry will see many advancements in both the procedure and machinery for doing this type of work.



A rotary type electric-motor-driven pipe cleaning machine, cleaning line that has just been taken from the ditch



The electric-motor-driven rotary pipe cleaning machine is here shown with its trailer, in which is located the generator set

Gulf Coast Conditions Render Difficult the Cementing of Large Diameter Casing

By K. C. SCLATER

On wells located in open bodies of water « stormy weather » presents formidable difficulties that have no parallel on wells located on dry land

LANDING and cementing a string of 13⅜-in. A.P.I. casing at a depth of 4762 ft. successfully is, under the most favorable conditions, no easy task. When, however, the job is done with a cementing barge on open water at night with a 35- to 40-mile wind blowing it is worthy of record, especially in view of the fact that this is believed to be one of the longest strings of 13⅜-in. A.P.I. casing that has been run in any well outside of California, where a string of 13⅜-in. casing was set at 5030 feet.

Difficulties that may seem insuperable when encountered elsewhere are overcome as a matter of course when met with in the Gulf Coast region. These difficulties have to do with drilling operations carried out in lakes or open bodies of water under the most disagreeable weather conditions it is possible to encounter.

The well on which this job was done is the Pure Oil Company's Yount Lee No. 11 in the Sweet Lake field, Cameron Parish, Southern Louisiana. The string of 13⅜-in. A.P.I. casing, almost 4800 ft. long, was set at 4762 ft. with 300 sacks of cement in a 17½-in. hole that had been surveyed at 200-ft. intervals the entire depth. At no point was the deviation from the vertical more than two degrees. To the straightness of the hole, together with the large diameter, could be attributed chiefly the absence of trouble in the well and the successful completion of the job of running and cementing the casing.

In order to assure a good body of cement on the outside of the casing 60 ft. of cement was left inside the pipe. When the plugs were drilled out it was found that the cement had been properly placed.

While such an outline of the running of the casing and cementing of the well may make it appear that the job was simple, it does not begin to convey any idea of the adverse conditions under which it was carried out. A storm was raging at the time that whipped up the water, making the going very rough for the cementing barge. So strong was the wind that the tow-boat, which pulled the cementing barge to the location, had the greatest difficulty in going against the wind and fighting the waves, which were 4 ft. or more high.

While cementing was in progress the heavy waves and high wind kept the barge in constant motion; a motion so erratic that had the barge not been securely lashed and handled by experienced men the job would have been well-nigh impossible of accomplishment. These trying conditions were encountered despite the fact that the barge was moored in the lee of the derrick. The velocity of the wind was estimated at 35 mi. to 40 mi. per hr. and whipped up the waves to such an extent that a heavy spray blew across the derrick floor all the time the work was going on. As the job was done at night it added to the difficulties.

The successful completion of jobs of this kind in the face of such difficulties is a tribute to the skill and experience of those in charge of the work, and especially to the two drilling crews, who in this case proved very capable and made the most of the extremely adverse conditions under which they worked. For some time they had been eating wild duck as a regular part of their diet. This may account for their feeling so exceptionally fit on this wet cementing job.

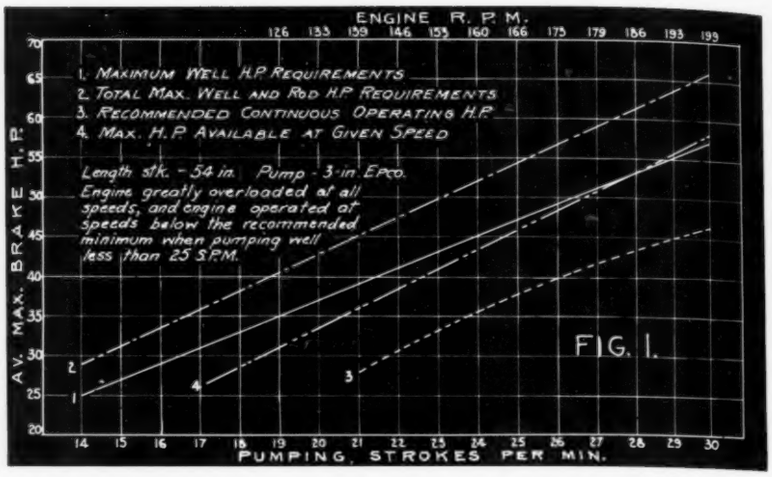
The work was in charge of Fred Dallas and P. G. Williams of the Pure Oil Company. All the members of the cementing crew, W. F. Chisholm, superintendent; Elmer Lacey, cementer, and Emil Nelson, helper, are men of long experience in this region on wells in open bodies of water. It was just one more difficult job for them. They arrived at the well just after dark and left just before daylight. This same cementing crew, in the early days of cementing wells located on water, had the experience of seeing one of their cementing trucks fall off the barge into 72 ft. of water.

Aside from the cementing of this well, the successful run made in landing the string of heavy casing was all the more remarkable in a well located as this one is. The fact that it was landed without a hitch is indicative of the foresight that is used on a job of this kind to guard against any possible interruption and delay. Special jobs on wells in this region are usually taken as a matter of course, for it is necessary to exercise the utmost care at all times in order to keep out of trouble.

Power Transmission Assemblies on Pu

By VAN D. BENNETT

Engineer, Derby Oil & Refining Company, Wichita, Kansas


ENGINE R. P. M.
126 133 139 146 155 160 166 175 179 186 193 199
1. Maximum Well H.P. Requirements
2. Total Max. Well and Rod H.P. Requirements
3. Recommended Continuous Operating H.P.
4. Max. H.P. Available at Given Speed
Length stk. - 54 in. Pump - 3-in. Epco.
Engine greatly overloaded at all speeds, and engine operated at speeds below the recommended minimum when pumping well less than 25 S.P.M.
AV. MAX. BRAKE H.P.
PUMPING STROKES PER MIN.
FIG. 1.

CURTAILMENT of oil production to a fractional part of the potential, as enforced today in the Mid-Continent and other fields, has altered the economic aspect of well-pumping operations to a marked degree. This is especially the case in pools the wells of which, though large, do not flow naturally but must be produced by pumping during the flush stage of production.

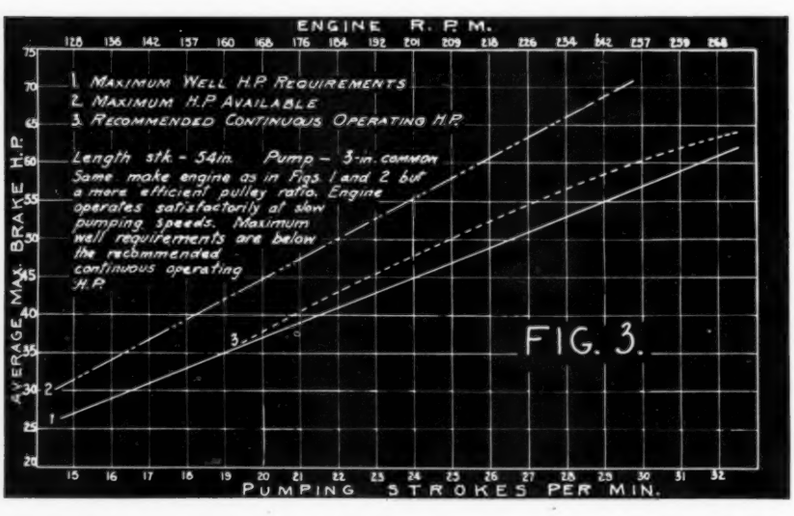
Drastic curtailment greatly prolongs the flush production period in pools of this type. It results also in a reduction in the rate of revenue return to the operator that frequently is entirely out of all proportion to the reduction that can possibly be made in the cost of drilling and equipping wells. The period of amortization is extended in many cases five-fold to ten-fold, thus making it almost impossible to reduce in a corresponding degree the initial well investment charges. Since the latter continue to be fairly high, the operator is forced to seek some way to offset the serious decrease in revenue. A desirable means of doing this is by a reduction in well operating expense.

It is the recognition of this fact that has changed the economic aspect of well operation and the conventional production practices pertaining thereto. Formerly, the sole aim was to produce the largest quantity of oil in the shortest possible time without giving much thought to the rapid deterioration and destruction of pumping equipment that resulted. Today, in these fields that have to be produced by individual well-pumping units during the flush production stage (only fields of this type are considered in this article), the objective of the operator is to produce his daily quota of oil at the lowest unit cost and to reduce wear and tear on pumping equipment to the minimum.

One of the most important phases of well operation leading to economics is an understanding of the relationship of a correct power transmission assembly to efficient engine operation and also the elimination of sucker rod trouble.

In prorated fields of the type under consideration a correct power transmission assembly for wells should be selected with one primary object in mind, that is, to obtain a slow motion of the rods and surface equipment and at the same time get efficient performance from the prime mover. Pumping at the rate of 16 to 22 s.p.m. will be here regarded as a slow pumping speed, for under competitive conditions in these flush fields the speed would range from 26 to 36 s.p.m., depending on the capacity of the individual well to produce.

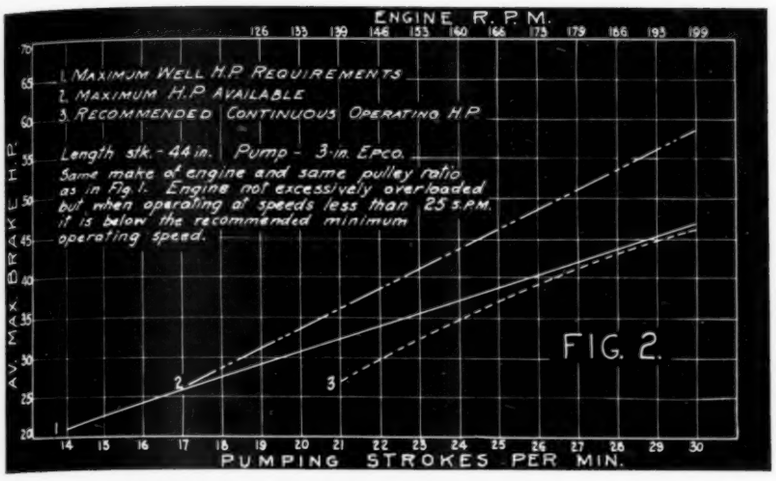
Few operators question the economic value of a slow pumping speed. Slow pumping speeds usually result in a reduction, if not elimination, of sucker rod breakage, which is a major item in lease operation expense and therefore one that is carefully considered by all operators desirous of economic operation. Another advantage of slow-speed pumping sometimes results from the assistance that the weight of fluid outside the tubing lends in lifting the column of fluid inside the tubing. Obviously, a higher fluid level can be maintained outside the tubing during slower withdrawal of fluid. This assistance will be reflected in the smoother operation of surface equipment, in reduced horsepower requirement from the prime mover, and in lessened rod stress. Where the well is drilled close to bottom water, or where edge water is encroaching, slow-speed pumping will reduce the hazard of water coning, which is caused by too rapid withdrawal of fluid from the well.


ENGINE R. P. M.
128 136 142 151 160 168 176 184 192 201 209 218 226 234 242 251 259 268
1. Maximum Well H.P. Requirements
2. Maximum H.P. Available
3. Recommended Continuous Operating H.P.
Length stk. - 54 in. Pump - 3-in. common
Same make engine as in Figs. 1 and 2 but a more efficient pulley ratio. Engine operates satisfactorily at slow pumping speeds. Maximum well requirements are below the recommended continuous operating H.P.
AVERAGE MAX. BRAKE H.P.
PUMPING STROKES PER MIN.
FIG. 3.

When using a constant pulley ratio, any reduction of the pumping speed necessitates a reduction in the speed of the prime mover. Some operators, sensing the desirability of a slow pumping speed, have obtained it by the simple expedient of reducing the speed of the gas engine. This method of slowing down the pumping speed may or may not be employed without sacrificing engine efficiency, depending upon the pulley ratios of the power transmission assembly and the type of gas engine used. Because of this practice, in-

Pumping Wells »

• Correct Pulley Ratios an Important Factor in Reducing Operating Costs


ENGINE R.P.M.
126 133 139 146 153 160 166 175 179 186 193 199
1. MAXIMUM WELL H.P. REQUIREMENTS
2. MAXIMUM H.P. AVAILABLE
3. RECOMMENDED CONTINUOUS OPERATING H.P.
Length stk. - 44 in. Pump - 3-in. Epco.
Same make of engine and same pulley ratio as in Fig. 1. Engine not excessively overloaded but when operating at speeds less than 25 S.P.M. it is below the recommended minimum operating speed.
AV. MAX. BRAKE H.P.
70 65 60 55 50 45 40 35 30 25 20
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
PUMPING STROKES PER MIN.
FIG. 2.

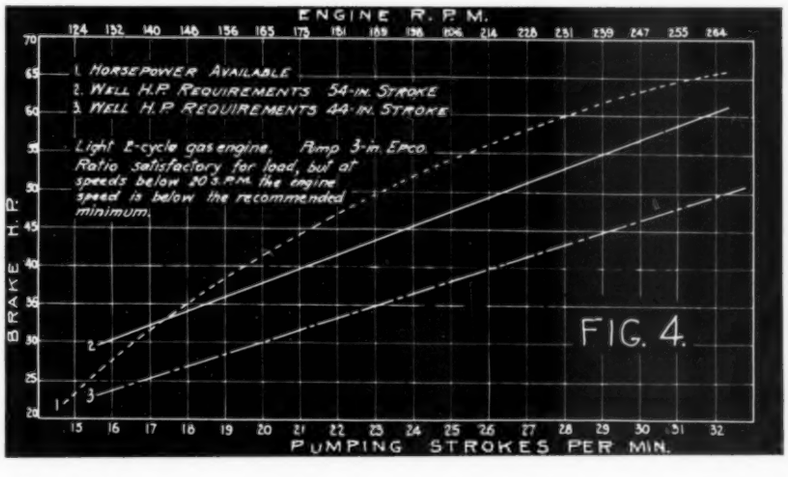
stances may be cited where gas engines are being operated too slowly for efficient operation. It is found that excessively slow engine operation produces three conditions that are very undesirable from a mechanical efficiency viewpoint.

The first of these conditions is that resulting from the operation of the engine at speeds below the manufacturers' recommended minimum. It is a generally accepted belief that most of the newer types of 2-cycle gas engines for oil field pumping service should never be operated below 165 r.p.m., for in order to develop the horsepower, the push of the piston must be heavier, as horsepower is a function of pressure, piston area, length of stroke, and r.p.m. As the piston area and length of stroke are constant, when the speed is decreased the pressure must increase in order to develop the same horsepower. Applying this to a well, it is of course true that when the speed of the engine decreases, the speed of the pump, and consequently the horsepower required, decrease. However, as can easily be seen from the curves plotted (Figs. 1, 2, 3, and 4), the rate of decrease is different for different well conditions. Due to a constant pulley ratio, the well horsepower curve is a straight line, the slope of which is much less than the engine horsepower curve. Thus, the horsepower required from the engine does not decrease so rapidly as the horsepower output of the engine, hence the pressure must go up when the speed is reduced. This causes heavy pounding at speeds below the recommended minimum, a condition that is hard on all parts of the engine, due not to the pounding alone but also to increased cylinder temperature. The condition is similar to that of the laboring of the engine of an automobile when trying to climb a long steep hill in high gear at slow speed.

Second, it is observed that the horsepower required by the well is sometimes greater than the horsepower the engine, because of the low speed, can deliver, thereby resulting in a highly overloaded condition of the engine. For example, it was found in one case that when the engine developed 34 hp. at 133 r.p.m., 37 hp. was required at the well. The slower the pumping speed on this well the greater the difference between the required horsepower and the available engine horsepower. Under this overloaded condition the deleterious results on the engine and its operation are the same as those observed when an engine is operated below the recommended minimum speed.

Third, running engines at a speed below their recommended minimum has a detrimental effect on pumping equipment and sucker rods. Much has been heard about the variable torque of a single-cylinder gas engine and the heavy strain that it puts on the surface pumping equipment, and that in many cases to it can be traced the cause of sucker rod failures. The background of these charges lies in having adopted improper ratios in the power transmission assembly. When operating below the recommended minimum speed, or when heavily overloaded, the engine will pound. This pounding is transmitted to the surface equipment and rods. When operating under correct conditions of speed and load, however, the heavy flywheels store energy between impulses that is eventually fed out during the cycle in a smooth even flow. The flywheels are so designed that the coefficient of fluctuation is very small. Numerous dynamometer tests of pumping wells show that under correct operating conditions a gas engine does not transmit any detrimental strains to the surface equipment or the rods.

It is obvious, therefore, that even though a slow pumping speed is conducive to economy it should not be attained at the expense of inefficient engine operation. On many wells in fields of the type under discussion the original installation of the power transmission assembly was made with the purpose of obtaining efficient engine operation at the high speed


ENGINE R.P.M.
124 132 140 148 156 165 173 181 189 198 206 214 223 231 239 247 255 264
1. HORSEPOWER AVAILABLE
2. WELL H.P. REQUIREMENTS 54-IN. STROKE
3. WELL H.P. REQUIREMENTS 44-IN. STROKE
Light 2-cycle gas engine. Pump 3-in. Epco. Ratio satisfactory for load, but at speeds below 20 S.P.M. the engine speed is below the recommended minimum.
BRAKE H.P.
70 65 60 55 50 45 40 35 30 25 20
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
PUMPING STROKES PER MIN.
FIG. 4.

necessary for fast pumping under unrestricted competitive production practice. Most operators now realize that the return to unrestricted production in these fields still may be remote and so are changing power transmission assemblies to fit the requirements of slow-speed pumping.

These changes are very simple and usually comparatively inexpensive, requiring only a change of belt pulley. Belt reduction ratio can be increased either by enlarging the diameter of the driven pulleys or decreasing the pulley diameter.

The information from which the curves on the accompanying charts were plotted was obtained from different power transmission assemblies in use on wells in a recently developed area in Kansas. The approximate horsepower requirements at various speeds are plotted against engine speed and horsepower. All these wells are equipped with 3-in. tubing and are approximately 3000 ft. deep. With this information, and the number of strokes per minute as a variable, the curves of horsepower requirements for the well were plotted. An overall efficiency of 45 per cent, which is generally accepted for the purpose of calculation, was assumed.

Fig. 1 indicates a well condition that is probably an exception. It shows the impossibility of obtaining a slow pumping speed with the pulley ratio then in use, which was evidently designed specifically for fast pumping speeds under competitive operation. This particular well had an auxiliary rod pump attached by a crank and connecting rod to the main crankshaft. As extra horsepower was required to operate the auxiliary pump it aggravated an already considerably overloaded condition. A change of pulley ratio in this instance was imperative.

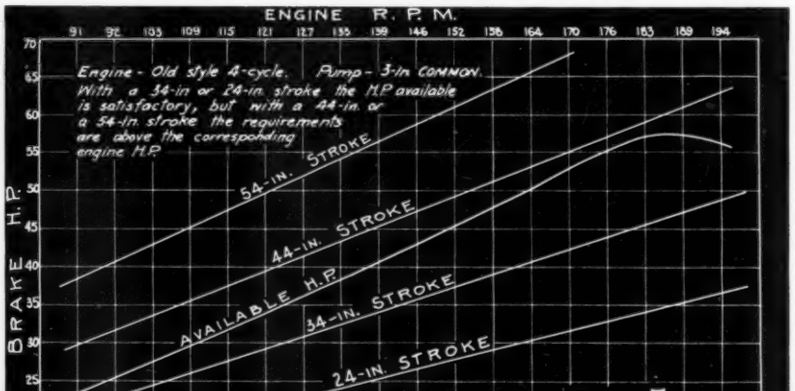

ENGINE R. P. M.
91 97 103 109 115 121 127 133 139 146 152 158 164 170 176 183 189 194
Engine - Old style 4-cycle. Pump - 3-in COMMON.
With a 34-in or 24-in. stroke the H.P available is satisfactory, but with a 44-in. or a 54-in. stroke the requirements are above the corresponding engine H.P.
54-IN. STROKE
44-IN. STROKE
AVAILABLE H.P
34-IN. STROKE
24-IN. STROKE
BRAKE H.P.
70 65 60 55 50 45 40 35 30 25 20 15
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
PUMPING STROKES PER MIN.
FIG. 5.

Fig. 2 represents a less exceptional condition. The engine and pulley ratio is the same as that in the well from which the curves in Fig. 1 were plotted, but the length of stroke has been shortened to 44 inches. It will be observed that although shortening the stroke relieved the overloaded condition on the engine somewhat, nevertheless, when running at 25 s.p.m. or less, the engine was still being operated at less than the recommended minimum speed.

Fig. 3 shows the curves for what is considered a very efficient power transmission set-up. The length of stroke is 54 inches. The same type engine is used as in Figs. 1 and 2, but the pulley ratio is different. On this well a 24-in. diameter pulley was substituted for a 30-in. pulley on the countershaft. The result was a highly satisfactory assembly for slow-speed pumping and efficient engine performance.

A different make of 2-cycle engine is represented in Fig. 4. The transmission assembly also is different, as no countershaft is used, and the pulley on the engine clutch is belted directly to the band-wheel. Many wells in the fields under discussion are equipped with this ratio and assembly. Although the available engine horsepower is ample to handle the well requirements at any speed or length of stroke, it is seen that when the pump is operating at less than 20 s.p.m. the engine speed is below the recommended minimum. A reduction of two inches in the diameter of the drive pulley would give a ratio approaching the ideal for slow-speed pumping on this well.

The curves in Fig. 5 show the horsepower necessary for different lengths of stroke as compared with the corresponding engine horsepower output. The engine in use on this well from which these curves were plotted was an old type 4-cycle engine. Using a 24-in. or 34-in. stroke the engine horsepower is satisfactory, but using a 44-in. or 54-in. stroke results in considerable overloading. Though the recommended minimum speed is much lower for this type engine than for modern 2-cycle engines, it is readily seen that this assembly lacks the flexibility of those previously discussed.

In reducing the diameter of the drive pulleys a question is raised as to how small a pulley can economically be used. There is no doubt that belt speed and tension being equal, reduction of pulley size decreases the life of a belt; but within a reasonable range the accompanying reduction of belt speed offsets this adverse factor. In practice, the use of 10-in. motor pulleys and 12-in. countershaft pulleys has not resulted in excessive belt wear on wells of moderate depth. It is not believed that the small reduction herein recommended to increase engine efficiency at slow pumping speeds will prove in any way detrimental to the belts.

The conventional pumping equipment used by most operators is designed by the manufacturers for continuous operation. It is manufactured with the expectation that it will be given hard, rough usage and some abuse. If this same equipment is used with care, using slow pumping speeds and intermittent operation, it is obvious that its useful life will be greatly extended. Efficient gas engine operation should be kept in mind when installing power transmission assemblies, for correct pulley ratios will result in better engine performance, will increase the ability of the engine quickly and easily to adjust itself to variation in load, and will do much toward lowering maintenance and repair costs.

So far as pumping equipment is concerned, replacements, repairs, and the attendant labor costs should be practically eliminated in flush, prorated pumping fields. An efficiently designed power transmission assembly will facilitate reduction in these items of expense. In this way, producers can effect a reduction of operating costs that will partially compensate them for their present diminished income.

Besides the benefits gained from a reduction in the operating and maintenance costs of surface and well equipment, the advantages that accrue to the well itself by reason of the steady operation of the well with a minimum of interruption are not to be overlooked. Conditions in the well under these steady operating conditions can be maintained that will result in a higher ultimate recovery. Cleaning-out and remedial work on the well itself will be required less frequently when rod jobs and tubing jobs are held to the minimum. These are some of the more intangible gains that result from having a properly designed power transmission assembly on a pumping well.

Diatomaceous Earth— Origin, Preparation and Use in Weir Process

Due to Fragility Methods of Handling at Plant Require Special Study

By RALPH BRADY
Research Chemist

DIATOMACEOUS Earth is a fossilized deposit of the remains of several hundred varieties of small plants, together with traces of scilia of small marine animals of a sponge-like structure. These plants occurred in times past in both salt and fresh water bodies. They are commonly noticed in the living state in stagnant pools of water in the form of green-brown scum, the conditions necessary to their growth being heat, moisture and light. Other colonies may be found on the surface of moist rocks mixed with other organisms or on the stems and leaves of water plants or floating debris in a fur-like coating. Marine forms are found attached to marine vegetation and in the stomachs of shellfish. Marine and fresh-water forms are frequently found in juxtaposition, the marine forms being carried inland by tidal rivers and fresh-water forms carried far out to sea by natural river currents.

The extreme minuteness of these individual particles can only be appreciated by microscopial examination. A specimen measuring 0.005-in. is about the average length dimension found in the species best suited for use as a filter aid. The variety of forms assumed by these minute organisms is astonishing, upwards of 5000 separate and distinct shapes having been classified to date.

The predominant shape found in commercial filter aid is the Cosinodiscus Perforatus, a disk-shaped diatom about 0.005-in. to 0.030-in. in diameter and a thickness of 0.0001-in. to 0.0006-inch. Under 900 diameters magnification the disk appears dotted with minute holes or depressions arranged in generally exact geometric grace. In variant forms the perforations seem to be irregular and of intermittent spacing. This form is also varied in multitudinous arrangements of solid centers, annular rings, segment-shaped solid (unperforated) areas and variations of concentric and radial alignments of perforations. Variations of the disk family are almost as varied as the designs executed by nature in the snowflake.

The diatom is one of the most prolific as well as one of the most generally distributed products of nature. This, coupled with the fact that it is one of the earliest forms of primary life, makes it easier to realize the enormous amounts of this material available in the natural state.

Diatomaceous Earth is found in nearly all parts of the world in varying degrees of purity. The immense deposits of nearly pure earth limit commercial exploitation to few localities, however. Geographical location, transportation facilities and climate are other factors, which further limit deposits to the workable class. The United States leads in the production and use of this product. In one region in California it has been calculated that within an area 2½ miles square, there exists at present more than 100,000,000 tons of Diatomaceous Earth.

Dependent on the geographical and geological characteristics of the deposit, is the type of mining employed. In most cases, removal of an overburden of from 6 to 20 ft. uncovers the deposit, which is mined in the conventional manner, with either hand or power shovels used, each method having advantages. Other deposits call for sub-surface operations, which are generally not economical in comparison with open-face quarrying. A third method has been pursued in Florida and Georgia, where the deposits are located under water or in swampy ground, where under such conditions, hydraulic or bucket dredging is resorted to.

As the first operation in the refining of Diatomaceous Earth is an air-drying one, an effort is made to quarry slabs of a size convenient for stacking, and not too bulky to preclude rapid drying. In a typical deposit to be quarried the earth is found in a laminated structure with seams running parallel to the strike of the bed. The laminations facilitate longitudinal fracture and in modern quarries the thickness of the slab is held between six and eight inches by skilled splitting. Various methods are employed to control the length and width of the mined slabs, some producers using machines similar to power ice-harvesting saws that run along the floor or the face of the quarry. Vertical seams of clay are encountered in some deposits. These are useful in limiting the length of the blocks.

After quarrying, the blocks of raw earth, ranging in size from two to four feet square and six to eight inches thick, are stacked in piles in such a manner as to give free circulation of air to a maximum area of each block. Exposure to the sun and wind from six to eight weeks reduces the moisture content from 50 per cent to 8 or 10 per cent. Modern plants substitute artificial drying for this step with varying success.

Following the drying step the slabs are run through a crusher and grinder, care being taken in this operation to control the steps so as to separate the diatoms with a minimum breakage. After grinding, air classification is resorted to for the separation of particles by size.

In appearance, Diatomaceous Earth, ready for use as a filter aid in Weir dewaxing, resembles a white to pinkish-colored flour. The individual particles are extremely fragile, the filter rate being readily affected by squeezing in the clenched hand. By listening carefully, a grinding, crushing noise can be detected during this operation. The material is extremely abrasive, is a good absorbent but a poor absorbant.

A typical analysis of a California sample shows as follows:

H_2O	5.25% by weight
Silica	89.05%
Alumina	4.10%
Brown (Fe_2O_3)	.60%
Lime (Ca O)	40%
Magnesia (Mg O)	.40%
Balance	.20%

The material, especially in the original state, possesses capillarity to a marked degree, evident in the constant dampness of the strata in the quarry face.

The structural shape of the finished particles of the products varies widely. As a result of the intermingling of the various shapes, the filter cake formed is extremely porous,

giving a very high filter rate when compared with a cake of equal thickness composed of particles of uniform shape.

Use in Weir Process

Diatomaceous filter aid is used in the Weir Process as a straining medium upon and in which the crystallized wax is deposited during a filtration. The process, which has been described before, is effective in dewaxing nearly all types of stocks and is rapidly being developed to a condition of commercial efficiency.

In operation of a Weir plant the stock to be dewaxed is blended in suitable proportion with a solvent, generally naphtha; the solution chilled to low temperatures, after which filter aid is added in amounts ranging from 20-lb. to 50-lb. of filter aid per bbl. of solution, the amount dependent on the amount of wax to be removed. After thorough mixing, the slurry is filtered in a desirable type of filter, the wax and cel remaining on the filter medium. The dewaxed solution passes through the filter and is later rerun to remove the naphtha. The filter-aid wax cake is washed with naphtha and recycled continuously, the wax being recovered upon distillation of the naphtha wash.

While the process seems to be relatively simple, attempts at commercial operation have revealed numerous difficulties both mechanical and operative, and, while not insuperable, have taxed the skill and ingenuity of the engineer. This article must be limited to a discussion of only the major problems and principally to those dealing with the handling and reuse of filter aid.

Perhaps the major consideration encountered in the use of Diatomaceous filter aid is its extreme fragility. The cost of filter aid necessitates its continuous use, it being out of the question economically to use it for a few cycles and then discard. Consequently, its fragility must be considered in the various inter-step handlings the material receives in the plant.

Filter aid as received from the mill in 80-lb. to 100-lb. burlap bags shows an efficiency of 100 per cent in an experimental filter rate efficiency determination. After a few days operation in a refinery, where it is subjected to pumping action in a centrifugal pump, a grinding action in conveyors, and a compression in a pressure filter, the efficiency drops to about 70 per cent. After two or three weeks in service the efficiency falls to 60 per cent and from here on gradually decreases to a minimum of 50 per cent.

Microscopic study of these phenomena reveals that an actual breakage of individual diatoms occurs, the long needle-like synedra breaking up in lengths as short as 10 per cent of the original length. The disk-shaped diatoms break up into segments and the sponge-like scilia crush. The net result is a general reduction in particle size, explaining the reduced filter rate.

This problem has been attacked by filter aid companies and considerable progress has been made by selection of diatoms of shapes and sizes calculated to have more rigidity, and by an after-treatment in which the material is strengthened by fluxing a salt over the particles.

The refiner has reduced breakdown to some extent by adapting a method of moving the material in the plant by means that impart the least stress to the individual particles. Even under ideal conditions, however, the breakdown is marked, and in converting laboratory results to plant predictions, it is conservative to take only 50 per cent of new filter aid efficiencies in calculating predicted filter rates.

Some question has arisen as to the effect of cake compression during pressure filtration. Examination of filter aid that had been continually subjected to pressure filter compressions only, no other breakdown factor existing, revealed that at 150-lb. pressure, considerable breakage occurs with a subsequent reduction in filter rates. Pressures below and above this mark were not investigated.

Commercial plants have been put to considerable expense in excluding moisture from the system. The presence of amounts as low as three per cent by weight in the filter aid affect the filter rate considerably, as well as resulting in partial plugging of line by chunks of filter aid agglomerated by freezing.

The sources of the moisture in order of their magnitude are: moisture carried into the system by atmospheric leaks, (especially troublesome in vacuum filters), moisture carried in solution and suspension in the oil-naphtha mixture, and moisture contained in a new cell charged to the plant.

Moisture from the atmosphere is practically excluded in a continuous pressure system, as the air, or inert gas, used to create filtering pressure is recycled continuously through a calcium-chloride or sulphuric-acid drier. In continuous vacuum systems, or batch pressure systems, where the operation is exposed intermittently to the atmosphere, rapid accumulation of moisture occurs, especially in cold areas. After a short operating period the results are noticeable for the effect is cumulative. Attempts have been made to reduce this condition by driers, but to date they have only been moderately successful.

If this main source of moisture is eliminated, moisture from the other two sources can be tolerated if the condition is not extreme. Storage of new filter aid in a warm dry place, coupled with careful drying of oil and naphtha will reduce to a tolerable minimum troubles arising from freezing.

A serious mechanical problem is present in devising a method of plant transportation that will operate effectively and yet result in a minimum amount of physical damage to filter aid. The physical constitution of filter aid can be likened to a mixture of lead pencils and various-sized saucers. Under compression the tendency is to break and interlace. As a result the angle of repose is very obtuse, and straight vertical pipe lines of large diameter have been known to bridge across. When moistened with either oil or naphtha this tendency is increased.

The most successful installations to date are those employing a centrifugal pump, preferably of the lowest speed possible and designed to generate just sufficient head to deliver the mixture of filter aid and liquid to the desired point. Reduction of velocities, by employing large pipe sizes, assists in reducing fracture of the particles, but increases the tendency of the filter aid to settle out of the carrier liquid.

The later designs of Weir plant follow this method of conveyance. Units in the plant are so located as to minimize transfer of the aid, and to utilize gravity fall in a vertical line when possible. Development of other mechanical methods of conveyance has not sufficiently progressed at this date to expect any relief in this direction.

Filter aid containing 80 to 90 per cent silica, is obviously very abrasive as the individual particles are hard (but brittle) resulting in rapid erosion of metal parts in contact. Employment of erosion-resisting metals, notably high-silicon iron, has reduced this difficulty considerably. In moving parts of the filter equipment, however, where it is impossible to use an erosion-resisting material, rapid wear obtains.

Rapid erosion of filter cloth, scrapers, packing and soft metal parts of the filter units are subject to frequent replacements. Proper design can eliminate these expensive repairs; filter types especially evolved for Weir plant work, now under consideration by several companies, have eliminated several undesirable features of the conventional continuous vacuum filter.

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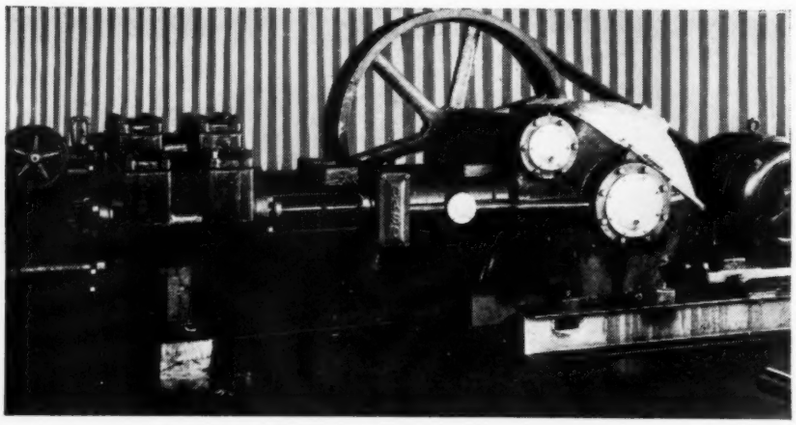
Terrain Survey Aids Routing of East Texas Gathering System

By WARREN L. BAKER



Gaso Horizontal Duplex Piston Power Pump in use on this line

Thorough Mapping of East Texas Enables Atlas Pipe Line Company to Build Economical Combination Gravity and Pressure System

PIPE line gathering systems, if properly laid out, should return a maximum of uninterrupted service at a minimum construction and operating cost. The building of an ideal assemblage of lines requires thorough planning, especially in such fields as East Texas, where conditions are not particularly suitable for the use of the gravity system of field gathering lines. A combination gravity and pressure system on its network of collection lines, totaling approximately 100 miles of pipe, in the East Texas oil field has proven efficient and economical for the Atlas Pipe Line Company, Inc., but the installation of this was not made until the company had thoroughly studied local conditions.

The operating method used by the company is somewhat different from the ordinary procedure in gathering crude from leases. It consists of moving the oil by gravity from lease stock tanks to a number of central points where, from small local pump stations, the crude is dispatched to main pressure lines traversing the length of the field. This method has permitted the company to take full advantage of the gravity flow conditions offered by the topography of the region and at the same time has saved miles of construction, which would have been necessary had these central points always been located at the lowest surface elevation.

The topography of the East Texas field is not generally adaptable for the laying of large gravity gathering systems, being composed of rolling hills and many low spots. In places the surface is so broken that the topographical barriers would necessitate radical departure from the desired course of the line if an attempt were made to employ a full-gravity system. It is such a vast area that a gravity system is inadequate to move the oil out fast enough, as the many creeks do not converge at any one central point.

Early in the life of the field, the Atlas Company made a close, careful survey of the terrain and mapped the course of each creek and low spot. The company has taken full advantage of the knowledge thus gained and has laid its gravity system of lines in the creek beds. By connecting to nearby leases excellent facilities for moving the oil by gravity from the lease stock tanks have been provided to bring a sufficient quantity of crude together at various central points so that small, semi-portable pump stations have proven profitable. From these stations the crude is pumped into the main pressure gathering lines.

To install such a system in a gigantic field like East Texas necessitated the laying of two main pressure lines into the productive area from the company's central pump station, two miles south of Longview, which location is the start of an 8-in. outlet line that transports the crude to Shreveport, La. The routes of these lines were carefully selected to facilitate movement of the oil. One line runs north from the central station to the Lathrop pool; the other travels to the southwest thirty miles, passing through the Kilgore (central) territory and continues south to the Joinerville field. Both of these 6-in. lines are intersected by spur lines, 4-in. to 6-in. in diameter, coming from the small local pump stations or concentrating points.

The pressure in the main lines ranges from 400 to 500 pounds, depending upon the number of pumps operating on the line simultaneously. An average of 3,000 bbl. per day has been gathered in this fashion since proration has been in force. The system could and did handle a much larger volume prior to proration.

The local pumping equipment is housed in small corrugated sheet metal buildings. The pumps, which vary in size from 4-in. by 6-in. to 7-in. by 10-in., depending upon the volume of oil they handle, are powered by electric motors with V-belt drives. The motors range in size from 25-hp. for the smaller stations to 100-hp. for the larger ones. Electric current for all motors is obtained from the power lines of the Southwestern Gas and Electric Company.

Gathering pumps of this type have a high salvage value, and for economical reasons the company has designed the system so that when the production of the field has reached a settled basis several of the local stations may be eliminated. This action cannot be taken until the output of the field is materially lower than its present daily recovery. The larger pumps have generally been placed at the lower end of the line, so that eventually the smaller pumps located between the bigger units and main pressure lines may be taken out.

Picture showing bullet hole made by gun through two casing strings and two inches of concrete

In Union Oil Company California Well Three Concentric Strings of Pipe and Cement are Penetrated by .45 Caliber Bullets to Admit Oil into Hole

By WALLACE A. SAWDON☆

Electrically Operated Gun Proves Effective For Perforating Cemented Casing in Hole

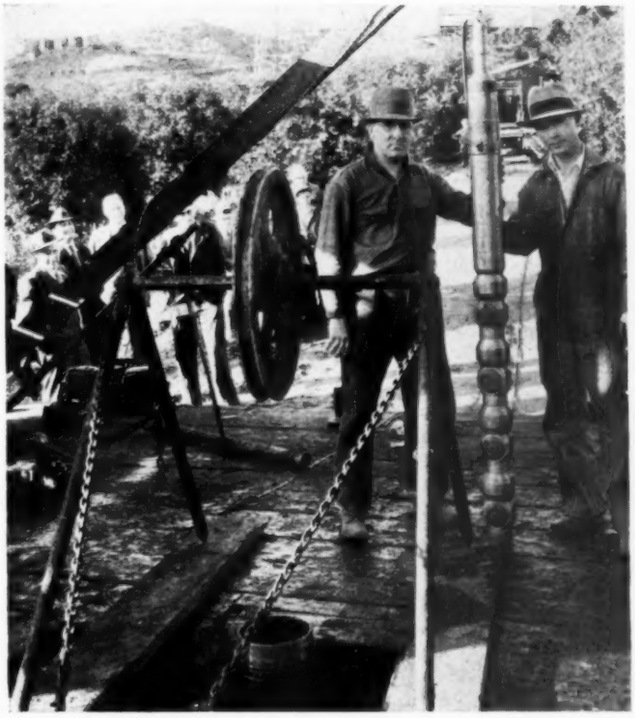
CONSIDERABLE experimental work has been done during the past few years in an effort to develop a gun for perforating single or multiple strings of casing which have been permanently set in a hole. Such strings are generally cemented, and the cement requiring penetration may be between strings or between the casing and the wall of the hole. The effectiveness of such a perforating gun can only be proved by results actually obtained in a well, and it was not until very recently that such a device thoroughly proved its practicability by actually making a producing well out of one that had previously been pumped dry in a lower zone.

Union Oil Company's well La Merced No. 17, in the Montebello field, California, had been drilled to a total depth of 2665 ft. with the effective depth at 2637 feet. Ten-in. casing had been landed at 2607 ft. with an 8-in. perforated liner, set between 2565 ft. and 2645 feet. Six-in. casing was cemented at 2600 ft., with the cement extending between it and the 10-in. string, upward beyond the point where the 12½-in. string was cemented (at 2420 ft.) and also extending to some distance behind the 10-in. pipe. The well in this condition—as shown in the accompanying drawing—was pumped dry in May, 1929.

When it was decided to perforate this well, some oil was found between 1703 ft. and 1728 ft., but an impression block run into the hole stopped at 1728 ft. The obstruction there encountered was driven with a 3½-in. bailer to 2010 ft., at which time standard tools were rigged up. With these tools the obstruction was driven down to 2608 ft. and the hole plugged at that depth. Oil was then found from 1650 ft. to 2000 ft., and was bailed out. The well was allowed to stand for 19 hours, after which time the hole was found to be dry. Water was run in and the perforating work started.

The perforations made by the gun were 0.45-in. diameter and began at a depth of 2604 ft. From 2604 ft. to 2565 ft. the bullets had to penetrate the 6¼-in. casing, the cement between it and the 8¼-in. liner, the 8¼-in. liner itself, the cement between the liner and the 10-in. casing, the 10-in. casing, and the cement between the 10-in. string and the wall of the hole. Above 2565 ft., the penetration was through the 6¼-in. casing, the cement between it and the 10-in. string, and the 10-in. casing itself. Shots were fired alternately on the opposite sides of the casing; that is, the second shot was in the direction opposite the first, and so on.

☆ Petroleum Engineer, Los Angeles.



An 8-shot Gun about to be run in La Merced No. 17. Alternating shots in opposite direction were used on this job

After the first four shots were fired from 2604 ft. to 2592 ft., oil entered the hole and rose to 2475 feet. Thirteen shots were then fired from 2587 ft. to 2560 ft., and the fluid rose to 2251 feet. After the next 13 shots were made (from 2559 ft. to 2531 ft.) the fluid level was found to be at 1900 ft.; but it rose to 1700 ft. after seven more shots were fired and the well had been allowed to stand idle for a day. By bailing eight hours the fluid level was lowered to 1800 ft., with an estimated production of 16 bbl. of oil.

During the next five runs with the perforating gun a 10-shot gun was used. Fifty holes, thus procured, were made without missing a shot, and while no speed was attempted, the time necessary to run the instrument in and out of the hole

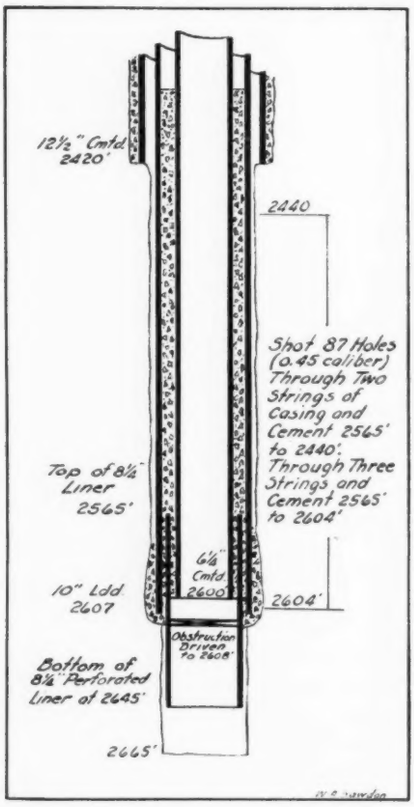
to make 10 shots was only 23 minutes. These 50 shots were made from 2513 ft. to 2440 ft. and completed the perforating work. The fluid level between the runs was at opproximately 1725 feet.

The fluid level reached 1695 ft. when the gun was last pulled from the well. The oil, after being bailed to 1760 ft., rose 20 feet in 30 minutes in the 6¼-in. casing and could not be bailed below 1835 feet. A 2½-in. pump, with 2½-in. upset tubing, was then run to 2480 ft. and the well put to pumping. In the first six hours it pumped 12 bbl., gross, of 18.5 A.P.I. gravity oil cutting 20 per cent. In 14 hours it had pumped 32 bbl. when a tubing leak was found. The daily production upon completion was found to be approximately 50 barrels.

The perforating gun that accomplished these remarkable results is a commercial development by the Lane-Wells Company of 4439 Santa Fe Avenue, Los Angeles, and, on the well described, was operated by that company, with the coöperation of the Union Oil Company, under the supervision of Henry E. Winter, petroleum engineer. The device consists of a series of perforating units threaded to each other and to a casing containing a control mechanism above, as indicated in the diagrammatic drawing. The holes in the casing and cement are made by 0.45-caliber steel bullets driven by a powder charge that is detonated by electrically energized thermal elements.

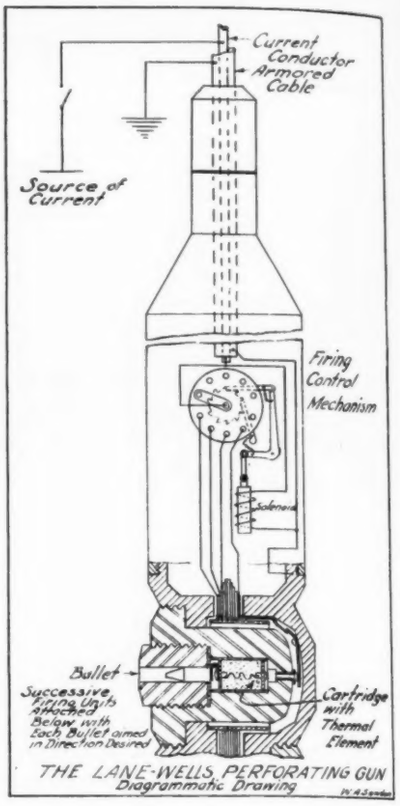
The instrument is lowered into the well on an armored steel cable, which carries a conductor for the electric current. When it reaches the depth at which the first perforation is to be made, the electric circuit is closed and the first shot is fired. The gun is then raised or lowered to where the next hole is desired. As can be seen in the drawing, the control mechanism contains a solenoid and an arm, which operates a rachet. When the current is next applied, the arm engaging the rachet advances the contact-finger to the next contact, at which time the second shot is fired.

An outstanding feature of the gun is its safety in operation. The powder cartridges can only be detonated by heat generated in the thermal elements by the application of electric current. The connection to the source of power is not made until the gun is in position in the hole and thus is avoided the chance of accidental discharge. The powder cartridge can be hammered or mistreated in any way without danger.


12½" Cmtd 2420'
2440
Shot 87 Holes (0.45 caliber) Through Two Strings of Casing and Cement 2565' to 2440'; Through Three Strings and Cement 2565' to 2604'
Top of 8¼" Liner 2565'
6¼" Cmtd 2600'
10" Ldd 2607
2604'
Obstruction Driven to 2608'
Bottom of 8¼" Perforated Liner at 2645'
2665'

Three strings of pipe and casing were perforated in Union Oil Company's well La Marced No. 17

While the shots used in the well described were aimed only in two directions, the gun can be made up to perforate in all directions. The position of the gun is not disturbed during firing since there is no recoil. In trials made above ground the device has been stood on end and fired without tipping it over. The shots can be fired successively or in groups, at any desired vertical intervals or the perforations can be distributed in spiral relation around the casing.



Drawing illustrating firing control mechanism

Assurance that each shot has fired is indicated by ammeter reading. The voltage during operations remains constant, so the amperage will change with the resistance.

Let Rc = Resistance in the cable
Rs = Resistance in the solenoid
Rt = Resistance in the thermal element and substitute in the formula E = RI

Before firing this formula is

$$I = \frac{E}{Rc + Rs + Rt}$$

When the shot is fired, the thermal element is destroyed and its resistance eliminated. The formula then becomes

$$I = \frac{E}{Rc + Rs}$$

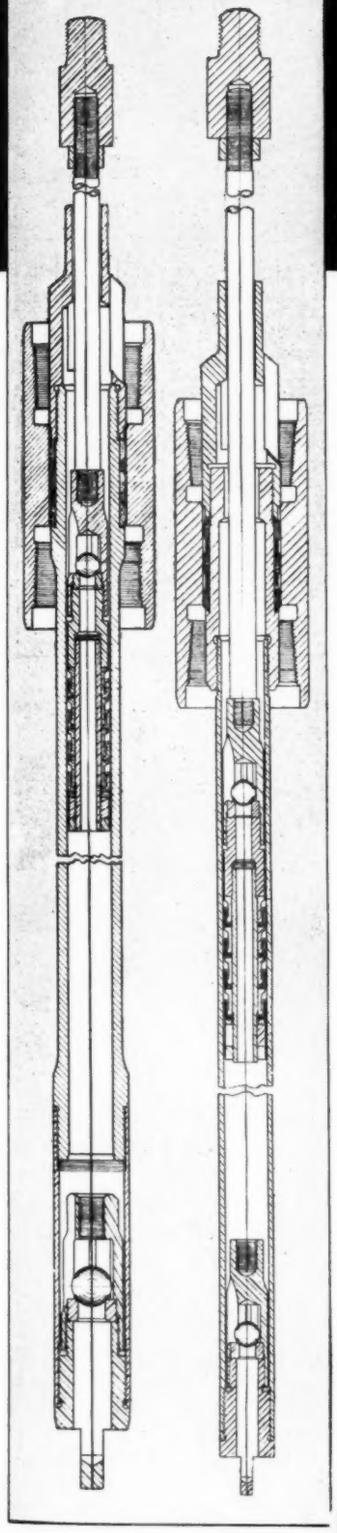
The change in amperage indicated on the ammeter then shows that the shot has actually been made.

The current used for the Union Oil Company well was taken from a motor-generator set driven by electricity from a lease power line. In this particular case, it was 150-volt, 1.5-amp. d.c., although the generator set is designed for 250 volts. For test purposes, the gun has been fired through 8500 ft. of cable plus sufficient resistance to equal 10,000 feet. When commercial current is not available, the generator is belt-driven by a gasoline engine.

Many perforating jobs have to be done under great fluid depths and the gun is hermetically sealed to make it adaptable for all conditions. The control mechanism is encased in a steel tube and this, together with the gun body below, will exclude all moisture. The cable is specially designed and is capable of carrying a load of eight tons while the 10-shot gun complete weighs less than 250 pounds. It is run in and out of the hole from a hoist mounted on a truck and driven by the truck engine through a power take-off.

If desired, the hoist apparatus and the firing mechanism can be so co-ordinated in operation that a series of shots can be fired, consecutively, at given intervals of time, while the gun is being raised and without halting its movement. This method prevents any possibility of "sanding up" or losing the equipment.

NEW Type 33-Better Pumps
Lower Prices-Full Range of Sizes



Nickel -Iron Barrel Design

Cold-Drawn Steel Barrel Design

"OILWELL" INSERT PUMPS

BUILT to the highest standards of quality, these NEW INSERT PUMPS bring you many features of improved design—at new low prices. Sizes begin with one inch. By applying the right size and design of Pump to a given well, you can combine highest volumetric efficiency with lowest lifting cost. It will pay you to consider these important points:

1. *Self-Contained Unit*—run in and pulled out on the rods; eliminates pulling tubing; can be seated on top of worn barrel.

2. *Small Barrel*—maximum efficiency; reduces load, and power expense; prolongs life of rods; ideal for continuous pumping; increases recovery of stripper wells.

3. *Simple Construction*—low initial cost; fewer parts; less upkeep.

4. *Special Packing*—prevents sanding up of pump when suspended in tubing or worn barrel.

5. *Two Designs (illustrated)*—available with various combinations of parts to meet different well conditions.

For complete information, ask for Leaflet No. 4-A.

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"OILWELL"

Refinery Combustion Calculations

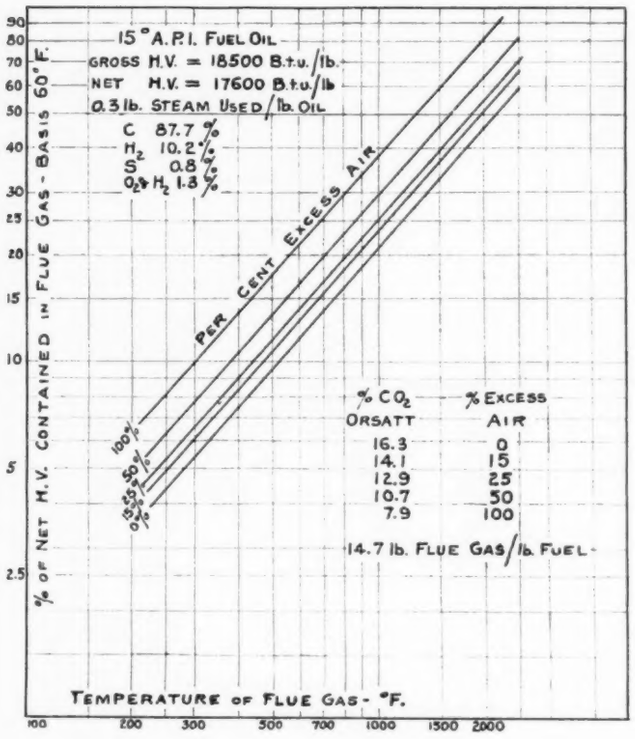


Figure 1
Fuel Oil Construction Chart

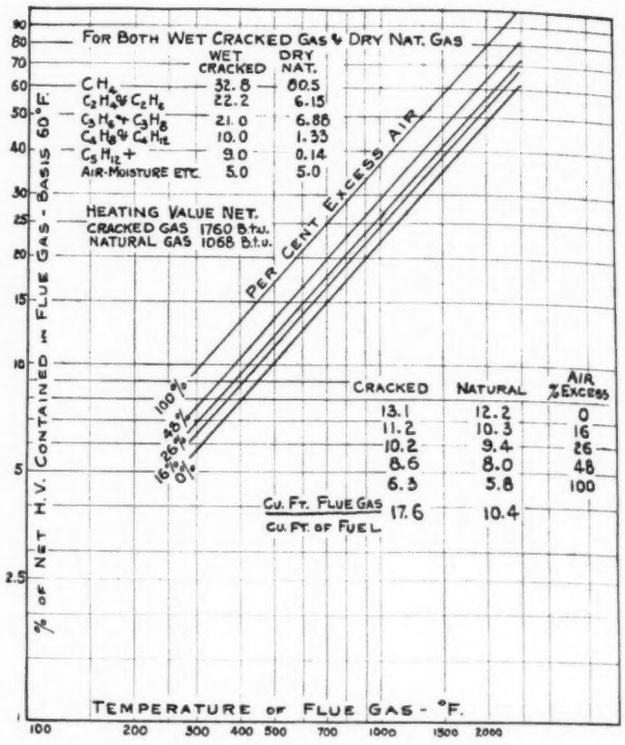

FOR BOTH WET CRACKED GAS & DRY NAT. GAS
WET CRACKED
DRY NAT.
CH4 32.8 80.5
C2H4 & C2H6 22.2 6.15
C3H6 + C3H8 21.0 6.88
C4H8 & C4H12 10.0 1.33
C5H12 + 9.0 0.14
AIR-MOISTURE ETC. 5.0 5.0
HEATING VALUE NET.
CRACKED GAS 1760 B.t.u.
NATURAL GAS 1068 B.t.u.
PER CENT EXCESS AIR
100%
48%
26%
16%
0%
CRACKED NATURAL AIR % EXCESS
13.1 12.2 0
11.2 10.3 16
10.2 9.4 26
8.6 8.0 48
6.3 5.8 100
Cu. Ft. FLUE GAS / Cu. Ft. OF FUEL 17.6 10.4
% OF NET H.V. CONTAINED IN FLUE GAS - BASIS 60° F.
TEMPERATURE OF FLUE GAS - °F.
100 200 300 400 500 700 1000 1500 2000

Figure 2
Gaseous Fuel Bombustion Chart

By W. L. NELSON
Professor of Petroleum Refining, University of Tulsa

THE generation of heat in the refining industry is a problem somewhat different from that in other industries. The major difference lies in the fact that petroleum oils are susceptible to the effect of temperature and the heating of them is a delicate operation. For this reason the highest rates of heating are not usually desirable and a considerable quantity of excess air (often 50 per cent) is used. This large excess of air fosters complete combustion and the elimination of the heat loss due to carbon monoxide in the flue gas.

The generation of heat in the refinery is also complicated by the use of a wide range of different and often undesirable fuels. Fuels such as asphalt, coke and acid-treating sludges are frequently available at the refinery; and since they are of little market value they are burned. These fuels can be burned satisfactorily but they do necessitate special burners and constant attention to the adjustment of the burners.

The amount of heat that can be obtained when burning a fuel is referred to as the heating value. If one pound of the fuel is burned at 60 deg. F. and the products of combustion are cooled to 60 deg. F. without condensing the water vapor in the combustion products, the quantity of heat that is evolved is called the Net Heat Combustion. If the water vapor is also condensed, the Gross Heat of Combustion is obtained.

In most industrial processes the condensation of the water vapor contained in the flue gas is impossible, hence the most logical basis for combustion calculations is the Net Heat of Combustion.

Continental engineers use the Net Heat of Combustion almost exclusively, while American engineers usually base computations on the misleading Gross Heat of Combustion. As an example, the following heat balances are for the same furnace, one is based on the Net Heat of Combustion while the other is based on the Gross Heat of Combustion:

Basis	(1) Gross H.V.=18,750	(2) Net H.V.=17,700
Useful heat or efficiency	70.0	74.1
Loss due to condensing with vapor from fuel	5.6	
Other losses	24.4	25.9
	100.0	100.0

The efficiency of 70 per cent based on the Gross Heat of Combustion is altogether unfair because no amount of skillful operation can ever recover the 5.6 per cent loss that is charged against the still by the use of the gross heating value.

Tables I and II show the combustion properties of common refinery fuels. It will be noted that if a limited group of fuels is considered, the combustion properties, such as per cent of CO_2 in the flue gas and the air required for combustion, are not greatly different. Considering a group such as the 22-27 A.P.I. fuels, even the heating value ranges through only about plus or minus 1 per cent. However, cracked fuels and straight-run fuels cannot be compared on a basis of gravity.

The most serious loss occurring in a furnace is the heat contained in the stack gases. If these gases can be cooled to 60 deg. F. (the basis for the heat of combustion) before entering the stack, no stack loss will exist. However, the gases are never cooled to as low a temperature as 60 deg. F., hence heat contained in the gases between 60 deg. F. and the stack temperature constitutes a loss.

The sensible heat loss that is due to the heat contained in the stack gases may be computed by laborious methods of heat

and material balances, but for practical purposes the stack loss charts, Figures 1 and 2, are entirely satisfactory. The use of these charts is not involved. As an example, referring to Fig. 1, a furnace is operating with 13 per cent CO_2 in the stack gas and the gases enter the stack at 600 deg. F. The 13 per cent CO_2 corresponds to approximately 25 per cent excess air. Under these conditions the stack loss is 14.7 per cent. If the stack were at 1000 deg. f. the loss would be 26+ per cent.

The atomization of oil particles is of primary importance in firing an oil fuel. Atomization is largely dependent on three factors, (1) the design of the burner, (2) the use of atomizing steam, and (3) the viscosity of the oil fuel. These factors are dependent one upon another and particularly factors (2) and (3). For instance, 0.3 lb. of steam per lb. of fuel may be entirely satisfactory when burning a non-viscous fuel oil, while as much as 0.6 lb. of steam may be required for a very viscous fuel oil or for a fuel that has not been heated to the proper temperature. Customarily, fuel oils are heated to such a temperature that their viscosity is under 30 centipoises at the firing temperature. This corresponds to a Universal Saybolt viscosity of approximately 150 seconds at the firing temperature. With a fuel at these temperatures the following quantities of steam are required for atomization in regulation burners:

Lb. Oil per Burner per Hour	Lb. Steam per lb. Fuel
400	0.415
600	0.267
800	0.20
1200	0.132

Since several burners are desirable the usual quantity of fuel fired through each burner in pipe still service is about 500 lb. per hr.

Many refinery fuels are almost solid at room temperature, hence precautions must be taken against the possible solidification of the oil in the line from the fuel tank to the burners. Commonly, the oil is circulated past the burners (arranged in series). In large plants the circuit may be so long that a parallel system of flow must be adopted. However, in any sort of system, a flow of oil must always be maintained in all parts of the system so that solidification will not occur.

Often a separate circulating system is maintained for each pipe still unit. With such an arrangement, minor fluctuations in the rate of firing may be adjusted for by controlling the pressure of the circulating system without adjusting the burner itself. By bringing the fuel oil line through the central control board the firing may be controlled without visiting the still. Such a system is quite satisfactory for normal firing adjustments if the fuel oil is clean.

TABLE I

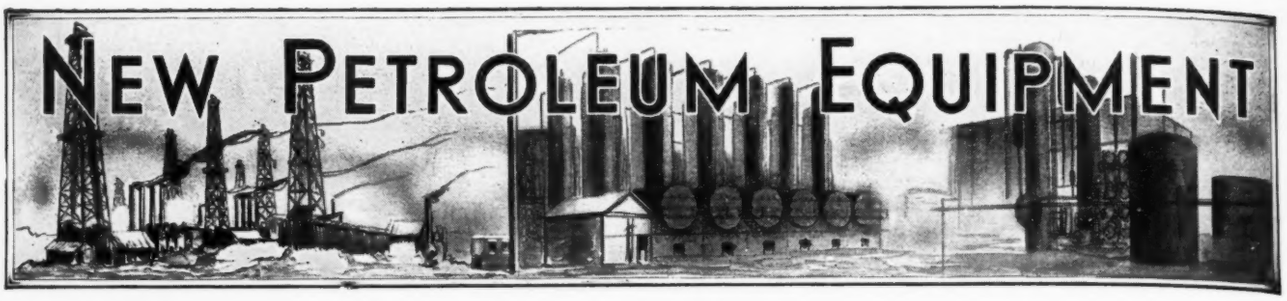
Material	M.W.	Density lb./cu. ft. at 60 deg. F	Analysis Volume Per Cent									Gross H.V. B.t.u./cu. ft.	Theo. cu ft. air per cu. ft. gas at 0% excess air	Theo. % CO_2 at 0% excess air
			CH_4	C_2H_4	C_2H_6	C_3H_6	C_3H_8	C_4H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}			
Methane	16	.0422	100	..	..	..	..	..	..	..	..	1009	9.57	11.65
Ethane	30	.0692	..	..	100	..	..	..	..	..	..	1795	16.75	13.1
Propane	44	.1162	..	..	..	..	100	..	..	..	..	2580	23.9	13.7
Butane	58	.153	..	..	..	..	..	..	100	..	..	3350	31.1	14.0
Pentane	72.1	.632*	..	..	..	..	..	..	..	100	..	21100**	37.9	14.2
Hexane	86.1	.664*	..	..	..	..	..	..	..	..	100	21000**	45.5	14.3
Octane	100.1	.687*	..	..	..	..	..	..	..	..	100	20800**	59.8	14.47
Natural Gas (Wet)	21.8	.0577	80	..	6.6	..	6.3	..	3.7	3.0	..	1360	21.58	11.99
" " (Wet)	3.5	.0541	81.3	..	9.8	..	5.6	..	1.7	0.9	0.5	1253	11.85	11.96
" " (Dry)	19.5	.0515	85.1	..	6.1	..	7.4	..	1.2	0.1	..	1200	11.34	11.9
" " (Dry)	18.6	.049	86.6	..	8.6	..	3.9	..	0.7	0.2	..	1160	10.95	11.89
" " (Dry)	17.3	.0458	90.7	..	6.2	..	2.1	..	1.0	..	..	1112	10.52	11.81
Cracked Gas (Wet)	35.0	.098	34.6	1.7	21.6	4.7	17.4	3.0	7.5	5.8	3.5	2058	19.38	12.91

*Sp. gr. of liquid 60/60.
**B.t.u. per lb. of liquid.

TABLE II

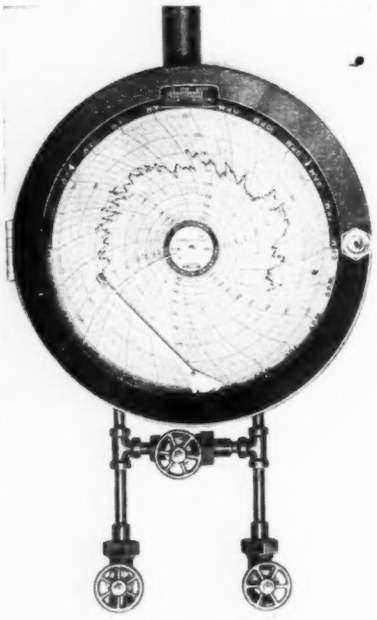
Fuel	A.P.I.	H_2O	Ultimate Composition				Per cent Undetermined Ash, etc.	Heating Value (as fired)		Lb. air per lb. fuel 0% excess air	% CO at 0% excess air
			C	H_2	S	O_2 & N_2		Gross	Net		
Topped Crude Oil—Ky	24.4	.....	87.1	12.53	0.22	.....	.15	19358	18168	14.35	15.6
Mid Continent Topped Crude	25.1	0.33	86.2	19.39	0.39	.....	0.69	19256	18076	14.1	15.6
" " " "	25.5	.....	86.5	12.38	0.46	.....	0.76	19182	18002	14.1	15.6
" " " "	25.3	.....	86.4	12.38	0.46	.....	0.46	19353	18173	14.3	15.6
Fuel Oil—Calif	15.6	.....	84.	12.6	0.75	2.55	0.10	18910	17720	14.25	15.4
Topped Crude Oil—Calif	26.2	0.89	85.8	12.09	1.19	.....	0.04	19053	18001	14.12	15.65
Mid Continent Topped Crude	27.1	.....	86.1	12.	0.35	1.1	0.45	19376	18241	14.1	15.7
Topped Crude Oil--Calif	18.7	0.05	85.6	11.4	1.6	.....	1.35	18607	17522	14.	15.8
Mid Continent Residuum	22.	0.05	87.4	11.1	0.42	.....	1.03	18778	17723	14.	16.
" " "	14.3	0.05	87.6	10.27	0.70	.....	1.38	18454	17479	13.7	16.4
Residual Fuel Oil—Ky	15.2	0.05	88.7	10.23	0.3	.....	0.72	18651	17677	13.8	16.4
Mexican Crude	13.6	1.85	83.7	10.2	4.15	.....	0.10	18710	17767	13.4	16.2
Residual Fuel Oil—Calif	16.5	0.05	87.5	10.17	1.14	.....	1.14	18319	17351	13.7	16.4
Cracked Fuel Oil—Calif	11.3	0.3	86.5	10.04	1.49	.....	1.67	18088	17128	13.5	16.4
Mid Continent Cracked Residuum	9.2	0.4	88.4	9.95	0.68	.....	0.81	18274	17324	13.7	16.6
" " " "	10.7	.....	88.5	9.92	0.77	.....	0.81	18293	17349	13.65	16.5
" " " "	8.6	.....	88.9	9.8	0.56	.....	0.74	18277	17345	13.7	16.6
Cracked Residuum—Calif	8.	0.05	88.3	9.5	1.2	.....	0.95	18084	17179	13.5	16.7
Residual Fuel Oil—Calif	7.6	0.10	87.5	9.38	1.37	.....	1.65	17970	17075	13.4	16.8
Mid Continent Residuum	8.1	0.25	88.5	9.07	0.67	.....	1.51	18077	17212	13.4	16.9
Cracked Residuum—Ky	3.3	.....	90.6	8.49	0.41	.....	0.50	17837	17030	13.4	17.1
Bituminous Coal—Pa	.....	2.5	77.8	4.8	1.2	6.2* 1.5	6.	13997	13543	10.4	18.6
" " —Mo	.....	2.6	72.6	4.6	1.8	6.3* 1.2	10.9	13533	13098	9.7	18.6

*Oxygen.



Brown Mechanical Flow Meter

THE Brown Instrument Company, Philadelphia, Pa., has rounded out its line of fluid measuring instruments by the addition of a series of mechanical flow meters. It is mentioned here as a series because this new flow meter has been developed in a number of combinations, including: (1) Square root and evenly divided charts; (2) Automatic planimeter; (3) Multipen, flow, pressure and temperature; (4) Compensation for pressure and temperature; and (5) Automatic control and recording.



This new line of mechanical flow meters is featured by a simple direct lever-actuating mechanism, by a large powerful float, by a pressure-tight bearing with grease reservoir, by a series of range tubes that permit changing the range of the meter without disturbing the orifice, and by a type of construction and assembly whereby the manometer may be taken apart and cleaned in the field without altering the calibration.

All recording models of this new meter can be provided with either hand-wound or electric chart drive, and either can be furnished in a variety of chart speeds. The hand-wound clock is mounted in a dustproof case with chromium-plated, stainless steel, and cadmium-plated parts used where these materials have proved superior in service tests. The electric clock is a radical departure from the general type of clock construction. It is driven by a 60 r.p.m. synchronous motor with the gearing mounted on stainless steel studs on the underside of a single plate. The electric clock plate also forms the base for mounting the control mechanism.

All models are designed with easily changeable range tubes to facilitate shifting a meter from one job to another without disturbing existing orifice conditions. Mounting means have been provided so that any model may be mounted on a floor stand, wall bracket, or pipe saddle, and the new type die-cast case permits flush mounting on a panel in keeping with other instruments in a flush mounted installation.

The weight of the instrument has been reduced as far as is consistent with a working pressure of 1000 lb., and is portable in the sense that it can be carried from one job to another.

Junior Control for Maintaining Liquid Level

A NEW junior type level control introduced by Shand & Jurs, Berkeley, Calif., has as its outstanding feature a thrust bearing to prevent pressure from causing friction on the shaft. It is equipped with a convenient connecting link that permits reverse action on the diaphragm valve. This control is also made in a master type for controlling extremely sensitive conditions such as inter-face work. In the latter service a different type of float is used.

Floats of various sizes are used to assure satisfactory conditions. Where the control is mounted directly onto a nozzle on the container, it is possible to use floats in sizes up to 10 inches, and with any desired length of float arm.

Any combination of signal lights may be applied to either the S. & J. Junior or Master controls. The method of attaching a Mercoid switch for controlling the lights is comprised of a special pointer which contains the brackets for holding the Mercoid switch. The entire unit may be enclosed in a metal box for protection.

Adams Lifting Jacks

TWO new jacks for use on pipe line work have recently been introduced by the Adams Manufacturing and Engineering Company of 2068 Belgrave Avenue, Huntington Park, Calif. They are designed for simplicity and economy in both new pipe line construction and repair work.

The Model "C" jack is hydraulically operated and requires only one man to operate. It handles any size pipe up to 16-in. and can be used either in the trench or on top of the ground. With a 10-in. lift it will raise or lower pipe the amount required in stages by holding the load with chains on hooks attached to the frame while the stroke is being changed. Being well balanced and light in weight it is easily handled. It is especially adaptable to lining up for welding; for cleaning, painting and overhead welding, and for all general repair work.

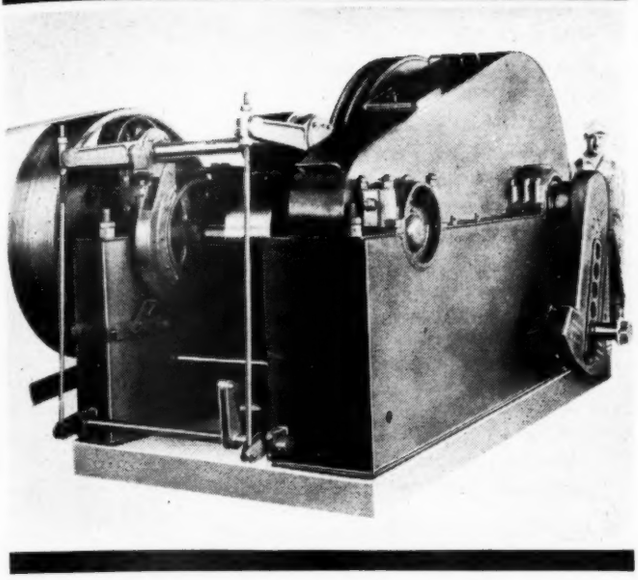
The model "AA" jack will raise or lower pipe up to 12 in. in diameter from or into the trench in one operation. This type is ratchet operated and requires only two men to handle, set up, carry along the line and operate.

Both models are made to order in larger sizes and full information regarding them will be furnished by the makers.

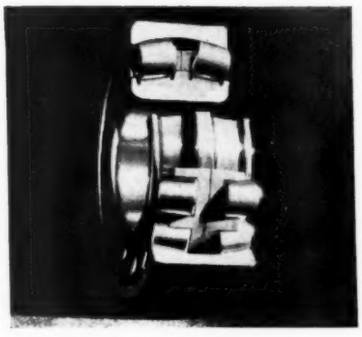
THE SKF GALLERY OF DISTINGUISHED PERFORMANCE USERS:

THE O C S MFG. CO.

TOUGH JOBS PROVE ECONOMY OF SKF BEARINGS



WORK . . . comes good and hard to equipment used in the oil fields. This is the kind of brute service that quickly proves the stand-up-ability of anti-friction bearings. It is under such exacting conditions that SKF Performance Takes Preference Over Price . . . reason enough why O C S selects SKF Spherical Roller Bearings for their Type 95F Universal Rig Front.



SKF Spherical Roller Bearings are made for the tough jobs of industry. They have plenty of stamina and ruggedness to stay on the job continuously without a bit of trouble and very little attention. Smoothly and surely they keep going, with a minimum of friction throughout a long life marked by freedom from wear . . . *and no adjustments.* All these factors mean real economy, the utmost reliability and the greatest return per bearing dollar.

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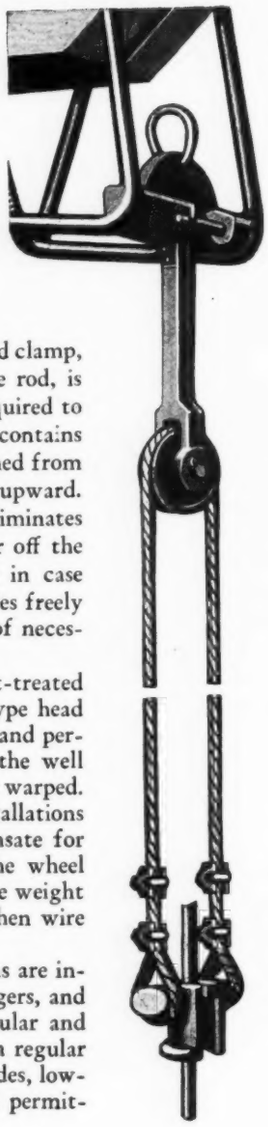
WHERE PERFORMANCE TAKES PREFERENCE OVER PRICE

● *You may buy a bearing as a bargain but try and get a bargain out of using it, for nothing is apt to cost so much as a bearing that cost so little.*

SKF
BALL AND ROLLER BEARINGS

Bridgeport Pumping Hangers



THE BRIDGEPORT MACHINE COMPANY, of Wichita, Kan., has announced a new and complete line of beam pumping hangers, that comprises eight models. These hangers, designed for operation on pumping wells up to 5000 ft. in depth, embody improved and unique features.

A 2-piece, wedge-type polished rod clamp, that holds and adjusts itself to the rod, is used on all models. No tools are required to adjust or install the clamp as it contains neither screws nor bolts. It is detached from the hanger reins by a quarter turn upward. The construction of the clamp eliminates the danger of throwing the hanger off the beam or of damaging the hanger in case the rods fail to drop. The clamp rides freely up and down on the reins in case of necessity.

Three types of alloy-steel, heat-treated heads are used. A knuckle joint type head absorbs much of the lateral motion and permits the hanger to line up with the well even when the beam is off center or warped. The solid type head is used on installations where it is unnecessary to compensate for side motion or crooked beams. The wheel type head is designed to equalize the weight of the well on the hanger reins when wire line reins are used.

Wire line reins and steel rod reins are interchangeable on all models of hangers, and hangers are designed for both regular and underslung beams. When used on a regular beam a saddle, in which the head rides, lowers the fulcrum point of the load, permitting a more nearly straight lift.

Worthington Automatically Primed Centrifugal Pumping Unit

ANNOUNCEMENT has been made by the Worthington Pump and Machinery Corporation, Harrison, N. J., of a new self-contained automatically-primed centrifugal pumping unit.

The new unit comprises an electrically-driven high efficiency ball-bearing centrifugal pump, mounted with its motor, on a fabricated steel bedplate, together with a Monobloc priming unit of the wet vacuum type, controlled by an electric pressure switch. The priming pump, or evacuator, is an adaption of the well-known "Hytor" pump, and is licensed to Worthington under patents of the Nash Engineering Company.

The evacuator is connected to the "high spot" of the suction volute by means of substantial tubing, and is sealed with clear water held in a reservoir built into the bedplate of the complete unit. The evacuator operates to remove air from the centrifugal pump, thereby causing it to be primed.

The evacuator motor is connected across the main pump motor line at a point between the starting switch and the motor, so that in starting the motor the evacuator motor also starts. The pressure switch is placed in the evacuator motor circuit and its pressure connection is piped to the discharge nozzle of the main pump. Whenever the discharge pressure of the main pump is below a predetermined point the pressure switch is held in the closed position. When the discharge pressure comes up to normal, the switch opens and remains open as long as the pressure is maintained. If the pump loses its prime the discharge pressure naturally drops. The pressure switch is thereby closed, causing the evacuator to operate until the pressure is again built up to normal.

Pumping Speed Reducer

CLARKE-MACGREGOR, INC., 5041 Santa Fe Avenue, Los Angeles, Calif., brings to the oil industry an improved type of speed reducer, manufactured by the Universal Gear Corporation. The new speed reducer is known as the Heliocentric Reducer.

The Heliocentric line of speed reducers comprise a complete line of single, double and triple-stage reducers in capacities from ¼-hp. to 150-hp., and in ratios ranging from 20 to 1 to 1,000,000 to 1. They can be furnished in either straight-line, vertical or right angle drive and in units from fractional horsepower to 50-hp., and ratios up to 200 to 1 in motorized speed reducers.

The line offers an entirely new mechanical patented speed reduction. A battery of plungers, operating reciprocally and actuated by an eccentric on the high-speed shaft, engages a stationary gear rack locked to the case. In other words, the high-speed shaft, in rotating, pushes the plungers radially outward in their plunger holders by means of its eccentric. As the plungers are pushed radially outward, they slide forward tangentially on the 45-degree-angle slope of each tooth, thereby carrying the plunger holder forward, rotating the slow-speed element.

G-R G-Fin Heat Transfer Elements

A NEW design of heat transfer surface has been developed by The Griscom-Russell Company, 285 Madison Avenue, New York City. Longitudinal fins are used on the outside of the heating elements, thereby increasing the exterior heat transmitting surface four to six and one-half times, as compared to the area of the same length and diameter of bare tubing and pipe.

In this patented design, which is known as the G-R G-Fin Heat Transfer Elements, the longitudinal G-Fins are equally spaced about the circumference of ¾-in. steel pipe and are securely fastened by a special contact. The gas, vapor or liquid of lower heat conductivity passes over the outside of the elements along the channels formed by the longitudinal fins and the fluid which transmits heat more readily flows through the pipes in the opposite direction, thereby obtaining the benefit of counter-current flow of hot and cold fluids.

G-Fin Elements may be furnished as separate units or assembled in a suitable shell to form a complete shell-and-tube heat exchanger.

Some typical applications of this design are compressor precoolers, inter-coolers, and after-coolers, hydrocarbon vapor sub-cooling condensers, fuel oil heaters, transformer oil coolers, etc.

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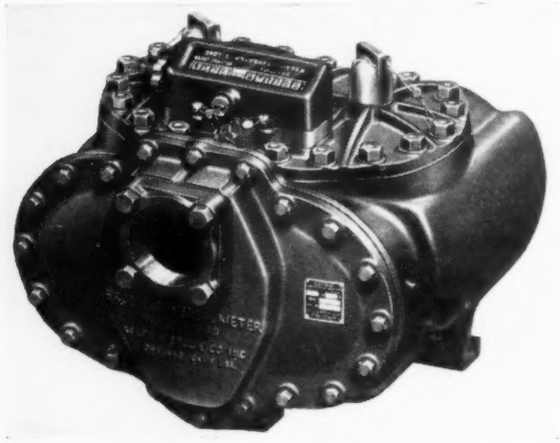
* *Manufactured by the National Supply Companies*

THE NATIONAL SUPPLY COMPANIES

Brodie Develops New Meter

A new meter has been developed by Ralph N. Brodie Company, known as Model X-300. It has an exceptionally low friction loss, according to the manufacturers, and maintains high speed under gravity pressure, requiring less power



to operate on pump installations, the power being supplied by the gravity flow of the liquid.

This new meter will start and operate on as low as a 1-inch head. It is equipped with a 3-in. inlet and outlet, has a capacity of 300 g.p.m. and will withstand a working pressure of 125 pounds.

It is claimed that this meter will operate satisfactorily either under gravity or under pump pressure and is particularly adapted for use at the loading rack; also on lines from tank cars or barges to storage tanks; in refineries and on pipe or gathering lines.

Details of this new meter can be procured from the manufacturers, Sixty-first and Lowell Streets, Oakland, Calif.

Fisher Fre-Flow Strainers

The Fisher Type 260Y Strainer, a product of Fisher Governor Company, Marshalltown, Iowa, is designed to efficiently remove all dirt, scale, or other foreign material, yet pass pipe line capacity on a low pressure loss. Designed with large free area through the renewable screen, offering practically no more resistance to the flow than a pipe bend and particularly constructed for use on pipe lines carrying water, oil, gas, oil or steam.

The self-cleaning feature permits cleansing the screen by simply opening the blow-off valve. The device is installed ahead of any regulator, pump, trap, valve or other working apparatus using a piped fluid, for the purpose of increasing the life of the device.

The Fre-Flow Strainers have screwed connections, and for ease of pipe fitting, the semi-steel bodies have a hexagon shoulder at the inlet end. It is regularly furnished with nickel semi-steel, or cast bronze bodies and with electric weld lap seam, perforated bronze screens, having perforations of either 1/64-inch for air and gas or 1/32-inch for water and other liquids. Screens of other metals and perforations can be supplied when desired.

Fre-Flow semi-steel or bronze bodies are suitable for pressures up to 250 pounds and maximum temperature of 500 degrees F. on non-corrosive liquids, gas, air or steam.

Oxweld Cutting Attachment

The Linde Air Products Company, 30 East 42nd Street, New York, N. Y., has announced an improvement in the Oxweld Type CW-17 cutting attachment whereby the heating oxygen throttle can also be used as an oxygen shut-off valve for use during temporary stops in cutting.

The throttle has been redesigned and the valve packing improved to make the valve operate more easily. This redesign makes the Oxweld CW-17 cutting attachment more convenient than before.

The new type cutting attachment was developed to provide a general blowpipe suitable for all kinds of work. By simply unscrewing the head of an Oxweld Type W-17 welding blowpipe and putting on Type CW-17 cutting attachment exactly as the welding head is screwed on, the Type W-17 blowpipe can be used for cutting work as well as welding.

The cutting attachment is sufficiently small, compact and light to be carried around in the operator's pocket so that it will be instantly available when needed.

A Bigger TracTracTor

Another addition to its crawler tractor line has been announced by International Harvester Company, 606 South Michigan Avenue, Chicago, Ill. It is the new Model T-40 six-cylinder TracTracTor, a bigger and more powerful unit than the Model T-20 TracTracTor, which was placed on the market several months ago.

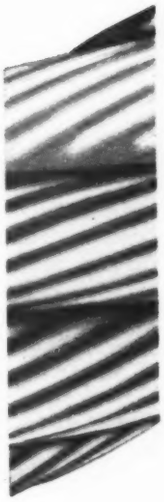
The T-40 develops a maximum drawbar horsepower of 40 and a maximum engine horsepower of 52 as compared to

the maximum drawbar horsepower of 23 and a maximum engine horsepower of 31 for the T-20.

Accessibility of working parts of the new T-40 TracTracTor is worthy of particular mention. Steering clutches, transmission and brakes may be easily inspected, adjusted or removed through top and rear cover plates, making for low maintenance cost. Special dust seals guard every shaft and bearing.

The large, positive-acting plate steering clutches, a new crawler-tractor feature, are in the rear compartment of the main frame. The steering brakes are immediately to the rear of the clutches. Efficiency of operation is enhanced by the use of forty-four ball-bearings. The six-cylinder engine is of valve-in-head design and has removable cylinders of 3⅝-inch bore and 4½-inch stroke.

114 SELECTED WIRES



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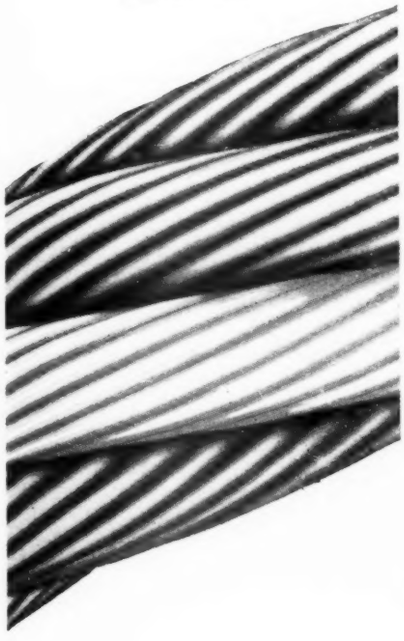

Broderick & Bascom Rope Company
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Yellow Strand Rotary Drilling Lines

Interesting Construction Problems On Wyoming Power Line

By FRANK B. TAYLOR

IN 1923, the Midwest Refining Company (now Stanolind Oil and Gas Company) found it advisable to build a 25,000-kw. electric plant in the Salt Creek field to furnish power for operations. Previously the operation of the wells was carried on by means of steam and gas engines and the engineers of the Midwest Refining Company had a rather wide choice of prime movers, since there are large coal fields near the Salt Creek field for steam generation and the field itself offered a supply of natural gas and oil for steam plants and internal combustion engines.

The Midwest Refining Company decided upon a steam-operated plant with two turbine-driven generators having a capacity of 12,500-kw. each, and two secondary turbo-generator sets of 500-kw. capacity each as standby. The steam for these machines was to be generated in water-tube boilers, using natural gas from the field as fuel.

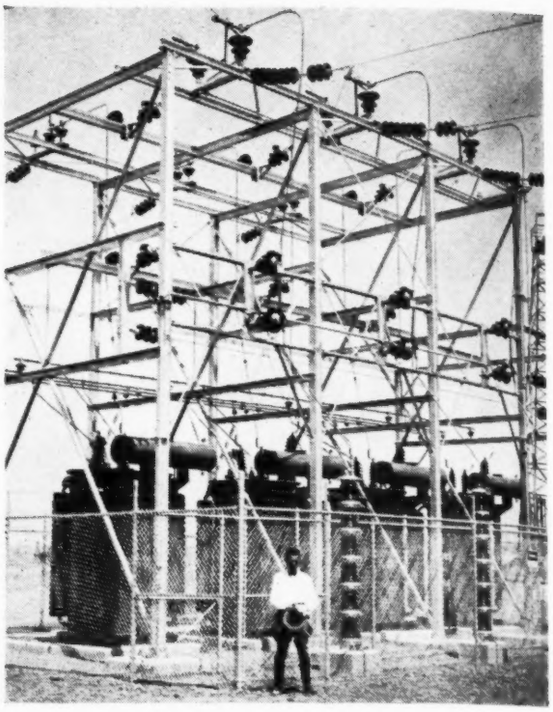
The work on this plant was started in October, 1923, and it was furnishing electricity for the field operation on January 1, 1925. Since that time it has been the only source of power for pumping and drilling the wells of the Midwest Refining Company in the Salt Creek field. As the field became fully developed, in accordance with the plans of the petroleum engineers for maximum economical oil recovery, power requirements for drilling were reduced to a minimum and there was less demand upon the electric plant for power.

The large Midwest refinery at Casper, however, needed power to refine the oil production of Salt Creek and other fields and, as the Salt Creek electrical plant was able to produce current at a very low cost compared with that produced at the Casper refinery, the matter of transmitting power from the plant at Salt Creek to Casper was considered. This led to the authorization of a transmission line from Salt Creek to Casper. The work on this line was commenced on May 4, 1932, and the first current was sent through the wires the following August.

This new transmission line is 38½ miles in length, connecting with the Salt Creek distribution system at the south end of the field. It is a 3-phase system and the current is carried on three cables made up of seven wires each, the center wire being of tempered bronze while the other six strands are of copper. The cable is size 2, and it has a tensile strength of 130,000 lb. per sq. in.

Joints were made with the Anaconda compression sleeve that makes a cold-welded joint by a special machine. Five transpositions were placed in the line between the field and the Casper refinery. Bus-bar connections were all made of copper tubing manufactured in iron pipe sizes.

The line traverses a rolling plains country, rather broken at the field end where the structural uplift of the Salt Creek anticline makes abrupt cliffs. The high altitude of the region also presented some problems on account of the greater liability of current losses. At the Casper end of the line a railroad and the North Platte river had to be crossed. The river and the railroad were crossed with the same span, a distance of 1050 ft. between supporting structures.



Salt Creek Sub-Station

The pole construction is of the H-frame type with a normal pole height of 45 ft. and the maximum pole height of 60 ft. at the river crossing above referred to. The cross arms are 6 in. by 8 in. by 22 ft. and all hardware on the line is hot galvanized. The insulators are of the suspension type and there are five discs 10 in. in diameter to each insulator. There is no ground wire on the line because of the high altitude and the danger of arcing.

All the structures at angles are heavily anchored. The railroad and river crossing has dead-end anchored structures at both sides and the same procedure is used where telephone lines are crossed. The dead-end structures have two head guys, two back guys and two side guys, giving six guys at each structure. Slight angles have single guys, while more severe angles have three side guys. Side-guyed structures are interposed at frequent intervals.

The sub-stations are of galvanized steel construction throughout and are protected from molestation by a 7-ft. mesh wire fence topped with three strands of barbed wire. The Salt Creek sub-station is equipped with 33,000-57,000-volt auto transformers using a 2300-volt delta-connected tertiary winding. Lightning protection is furnished by 69,000-volt thyrite arresters. The Casper sub-station is equipped with 57,000-2300-volt transformers.

The line is expected to start a current of 60,000 volts at the Salt Creek end of the line and deliver 57,500 volts at the Casper sub-station. Although three months ago the line was carrying about 2000 kw., this was increasing rapidly and at present the Salt Creek electric plant probably has a combined refinery and field load of 10,000 kw.

The line was constructed by the Denver contracting division of the Stearns-Roger Manufacturing Company, by whose courtesy the photograph is reproduced. The Midwest Refining Company accepted the line and have found it perfectly satisfactory in operation to date.

The Behavior of Occluded Gas in an Oil Sand Reservoir

By IONEL I. GARDESCU,☆ Ph.D., Petroleum Engineer and Geologist

Part IV. An Analytical Study of the Resistance Offered by Occluded Gas

CONCLUDING ARTICLE

At the close of article 3, which appeared in the January issue, experimental evidence was adduced to show that the rate of evolution of gas from solution depends upon two factors, viz., the concentration of gas molecules in solution; and the area of the interface along which free gas may be evolved. The effect of these factors in influencing the production of a well were also discussed. This brings us now to a study of bypass of gas.

Bypass of Gas

Bypass is the phenomenon of gas masses moving through the reservoir under the action of buoyancy and differential pressure towards the well. The gas masses are displaced by either of these forces only when their size is sufficient to permit the development of the necessary differential pressure which acts upon them.

Irrespective of position and distance from the well, buoyancy remains the same for gas masses of equal size, whereas the pressure gradient towards the well is maximum at the well and diminishes to zero with distance. Therefore, buoyancy is the more important of the two forces in the portions of the reservoir some distance from the well and consequently the gas in this area tends to accumulate toward the top of the sand. As the distance from the well diminishes, the pressure gradient increases and becomes a more important force than buoyancy, and the accumulation of gas tends to take place along the more porous portions of the sand because of the lesser resistance offered to gas masses. It will be recalled from equation [4]* that the maximum of P is reached when R_1 is equal to r, the radius of the interporous opening. A higher value for r, therefore, results in a smaller value of the resistance P.

It was shown that the degree of supersaturation plays an important part in facilitating the formation and growth of gas masses. A low degree of supersaturation permits the formation of only a relatively small number of gas masses. If this condition is maintained, these gas masses grow by diffusion and the masses located closer to the top grow larger because of convection currents. This condition is most likely to prevail at a distance from the well and, there, buoyancy causes the larger masses to move toward the top of the sand. The effect of pressure gradient is negligible because a low degree of supersaturation implies a small drop in pressure.

A high degree of supersaturation permits the formation of a larger number of gas masses. These masses will be individually smaller than the former if the total volume of the evolved gas is assumed to be the same. The more numerous the gas bubbles, the smaller is their size and the less their tendency to move in the reservoir.

The size of the occluded gas masses is the determining factor in the phenomenon of bypass.

The pressure gradient varies with the rate of flow and is independent of the size of the gas mass. Therefore, if the pressure gradient and buoyancy are the same, their effect is less on a gas mass of reduced size.

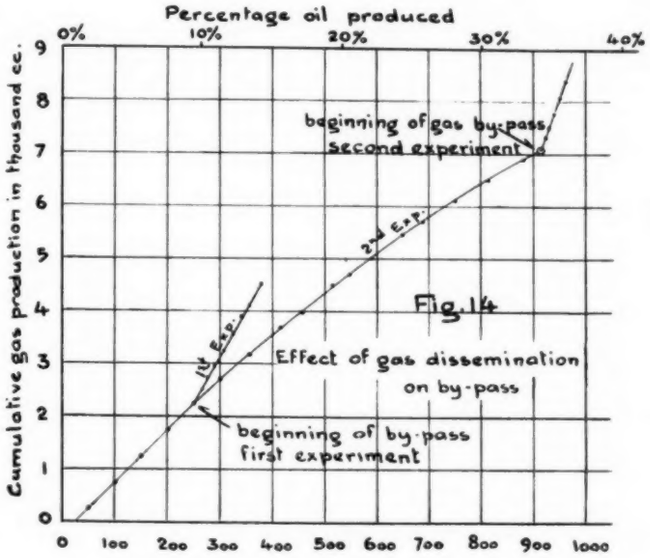


Figure 14: Cumulative oil production in cc.

Experiment VIII

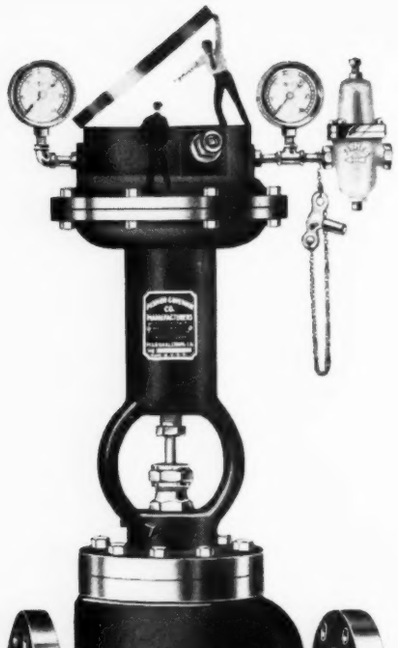
The following two experiments are intended to show the effect of size and distribution of gas masses on the phenomenon of bypass.

The apparatus described in experiment VII* was used.

The tank was filled with 2675 cc. of oil, in which 27,820 cc. of gas was dissolved at 415 lb. pressure. Measurements were made to ascertain that this pressure was that of saturation and that the reservoir was void of free gas. A valve at the top of the reservoir was opened, thus permitting the flow of oil. The degree of supersaturation in the reservoir was kept at low value by maintaining very low rates of flow. There was no evidence of escaping free gas because the occluded gas, which was forming at selective points, had not reached a sufficient size to be affected by buoyancy or by the small pressure gradient toward the outlet. The gas-oil ratio by volume was 10.4 when production started. This corresponded to the original gas-oil ratio of saturation. As production progressed, the ratio declined (Fig. 14) because the only gas produced was that in solution and the oil in the reservoir was slowly reduced in its gas content by the formation of occluded gas masses. No irregularity of flow was observed until 260 cc. or approximately 10 per cent of the oil was produced over a period of 42 hours. At that point there was a sudden increase in the gas-oil ratio that was caused by the escape of free gas from the reservoir. Although free gas was not produced at a uniform rate, the gas-oil ratio curve shows a remarkable uni-

☆ Professor of Petroleum Engineering, University of Pittsburgh.

* *The Petroleum Engineer*, Vol. 4, No. 4, January, 1933.



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formity. Unsuccessful attempts were made to prevent bypass by reducing the rate of flow far below any previous rates and also by completely stopping the flow. No effect was observed on the gas-oil ratio when the flow was stopped for long or short periods of time, or when the rate of production caused an increase in gas-oil ratio. The application of shock to the reservoir had absolutely no effect on either the pressure or the rate of flow of oil.

Experiment IX

Under conditions identical to those described above, the original pressure of 415 lb. was suddenly reduced to atmospheric by withdrawing from the tank 8 cc. of oil. This volume of oil represented the expansion of the fluid from a pressure of 415 lb. to atmospheric, and thus it was apparent that at the time the low pressure was reached, there was no free gas in the reservoir, or if gas bubbles were in the process of formation, their volume was of molecular dimension and could not be recorded.

At the moment when the 8 cc. of oil had been produced, the valve was closed and the tank struck with a hammer, causing the pressure immediately to return to its original value, which was indicative of a sudden evolution of gas. The evolution of gas took place around many nuclei because of the very high degree of supersaturation. The occluded gas must have occurred as a great number of small widely disseminated bubbles.

When the valve was open for production, it was observed that the rate of flow could be varied over a wide range without creating any appreciable drop in pressure. This was due to the fact that the surface of the numerous small bubbles was very large, which permitted a rapid evolution of gas when the pressure was lowered. The relatively small surface of the few larger masses in the former experiment permitted only slow rates of flow against a high back pressure. The gas-oil ratio in the second experiment corresponded to the first, as there was no escape of free gas with the oil and the original saturation of the oil was the same.

In the second experiment, no bypass of gas took place until 36 per cent of the oil in the reservoir was produced while in the first experiment bypass began as soon as 10 per cent of the oil was produced. The gas-oil ratio, which was 10.4 at the beginning of the second experiment, decreased to 5.4 when 36 per cent of the oil was produced and with the beginning of bypass, it increased to 28 (157 cu. ft. per bbl.) at which value it thereafter remained. It was impossible to prevent the bypass of gas by any possible means in either experiment. It is obvious that the retarding of bypass in experiment IX was due to the wide distribution and consequent reduced size of the occluded gas.

The experiments seem to indicate that a greater utilization of the gas energy is made when producing under conditions similar to those of the second experiment. The wide distribution of gas bubbles instead of impeding production as is erroneously believed, greatly facilitated production by permitting higher rates of flow and maintaining a more uniform distribution of pressure throughout the reservoir. Moreover, the duration of the natural period of flow and the ultimate recovery of oil would be consequently increased.

Experiment X

This experiment is intended to show that a low degree of supersaturation may be maintained over a long period of time without any gas evolving from solution. Results similar to those observed in Experiment IX may be obtained by the application of shock to the slightly supersaturated oil.

Conditions prevailing at the beginning of this experiment were identical to the original conditions of the two previous experiments.

The pressure of the reservoir was lowered from 415 lb. to

400 lb. and maintained at the latter pressure over a period of 42 hours. During the first 26 hours, 2.8 cc. of oil was produced and over the remaining period of time no production was detected. If the pressure of 400 lb. had been maintained over periods of time longer than 42 hours, it is believed that only an insignificant amount of additional oil would have been produced.

Following the lowering in pressure, the resulting degree of supersaturation was small and no gas bubbles could form in the reservoir. The 2.8 cc. of gas evolved is attributed to the growth of pre-existing gas masses by diffusion, but as the oil surrounding the gas masses was exhausted of gas, the process of diffusion from distant points became so slow that the growth of the gas masses apparently ceased. The amount of gas held in solution above saturation is calculated to be 1000 cc., which would represent a volume of free gas of 37 cc. at 400 lb. pressure.

At the end of the 42 hours, the reservoir was struck with a hammer and the pressure immediately increased more than 10 lb. During the next six minutes, 0.44 cc. of oil was produced against the same back-pressure of 400 lb. Wnen the reservoir was closed, the pressure built back to 410 lb., proving thereby that the newly developed gas bubbles were surrounded by oil, the gas saturation of which was at least 410 lb. Over a period of one hour after the application of shock, 6.29 cc. of oil was produced from the reservoir. At the end of the 42-hour run, the oil was apparently in a state of equilibrium because of the fact that the pressure and volume remained unchanged over a period of 16 hours. As a matter of fact, the oil was not in equilibrium but in a state of supersaturation as was evidenced by the creation of new gas bubbles when shock was applied. The pressure might possibly have been lowered below 400 lb. without destroying the apparent state of equilibrium as the minimum pressure is dependent upon the nature of the nuclei. This information, however, was unfortunately not available, since no work has been done on the problem of the relationship between the degree of supersaturation and the properties of the nuclei-forming substances.

Although the total volume of the newly formed gas bubbles was small, their number was large for when the pressure was reduced to 350 lb., 60 cc. of oil was produced in 30 minutes. The relatively small number of gas bubbles generated in Experiment VIII permitted a production of only 3.5 cc. over the same period of time, even though the pressure was lowered to 300 lb., whereas the large number of gas bubbles generated in Experiment IX permitted a production of over 200 cc. under similar conditions of pressure and time.

Field Application

The above experiments illustrate the advantages of wide distribution of gas masses. The most effective method of obtaining this wide distribution of occluded gas is that employed in Experiment IX. In natural reservoirs, however, this method can not be employed because the volume of oil that represents the expansion for the desired drop in pressure is so great that its instantaneous removal cannot be accomplished. On the other hand, a lesser degree of supersaturation may be established in a field, as was done in Experiment X. Here, the value to which the pressure is lowered is predetermined by the nature of the nuclei. At no point of the oil-bearing part of the reservoir should the pressure be lowered below that limiting value. The most difficult part of the problem would be that of removing relatively large volumes of oil while maintaining a relatively low pressure gradient in the reservoir. The lowering of pressure might be facilitated by drilling wells in the adjoining edgewater or gas zones. The gas wells should be produced against a back pressure equal to the limiting pressure, but the water wells may be produced at any rate desired as long as the drop in pressure does not exceed the limit-

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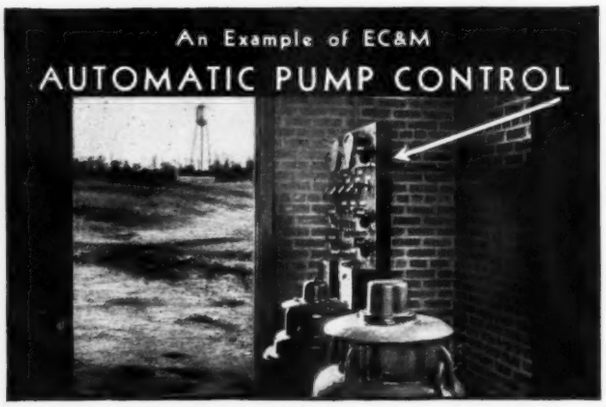

What is Your Problem?

Many hundreds of pumping stations are operated economically under the sole supervision of EC&M Automatic Pump Control. Some use deep well pumps, others have booster pumps. They operate in accordance with the demand. They function *only when needed* and *only as long as required* to meet the demand.

Consider, for example, the installation shown in the above illustration. This pump house contains 4 vertical motor-driven pumps. Two are deep well pumps discharging into a clear well; the other two boost the water from here to the tank shown in the distance located ¾ mile away. Indicated by the arrow is the EC&M Altitude Regulator Panel, which has all connections, both hydraulic and electric, made within the pump house; there are no pilot lines or control wires running to the tank. This ultra-sensitive unit starts and stops the pumps automatically in accordance with the levels in the tanks. An effective storage capacity is guaranteed at all times by extremely close regulation.

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ing pressure in the oil-bearing horizon. It is notable that the amount of oil that represents the expansion above the limiting pressure could be removed more quickly through the outside gas and water wells than by wells drilled in the oil-bearing portion of the horizon that should be produced against a high back pressure.

The time element in this case is of practically no consequence since the supersaturated oil will remain in a state of apparent equilibrium so long as the pressure is maintained above the critical point. When the desired degree of supersaturation was reached, shock could be applied by means of explosives. The advantages of creating a large number of small bubbles disseminated throughout the reservoir are obvious. The difficulties involved in reducing the oil in a reservoir to a condition of supersaturation prior to the application of shock are great, but not unsurmountable.

Producing in the laboratory 36 per cent of the oil from a sand reservoir opened at the top was not accidental, but the result of a careful study of the problem involved. In the field, it is necessary to study the problems, which are even more complex than those of the laboratory, if maximum production efficiency is to be obtained.

There is no complete cure for gas bypass in either the laboratory or the field, but bypass can be reduced. Bypass causes a loss in reservoir energy which presents a very serious problem of production. This loss is remedied only in part by repressuring, because bypass once established cannot be prevented.

In a recent publication[3] of the New York State Museum, Dr. Russell suggests the use of gas bubbles as a method of production. Preliminary experiments were made by forcing water with carbon dioxide in solution through a block of oil sand. The bubbles brought with them additional oil, and it is suggested that the same method be used in the field in connection with flooding operations. Unfortunately, gas bubbles do not travel through a natural reservoir the same as they do through a small block of sand, because the pressure gradient in a reservoir is so much smaller. The results would not be comparable in a field to those obtained by Dr. Russell, but would be more likely similar to the gas-drive operations as commonly used in several fields, notable among which is that of the Marland Oil Company (now Continental Oil Company) at Seal Beach, Calif.

Gas bubbles, as such, cannot be circulated and their value lies in the fact that they are held in place and thus prevent bypass.

ACKNOWLEDGMENT

The author wishes to express his appreciation and indebtedness to John T. Galey of Beaver, Pa., for helpful collaboration in preparing the manuscript of these articles.

[3]Russell, William L. Some Preliminary Experiments on Oil Recovery Processes. Circular 8, New York State Museum, Albany, N. Y., November, 1932.

New Dardelet Threadlock Licensee

The Russell, Burdsall & Ward Bolt and Nut Company of Port Chester, New York, has been licensed by the Dardelet Threadlock Corporation to manufacture and sell "RIVET-BOLTS" and other bolts and nuts with the Dardelet Self-Locking Thread.

Old established, progressive engineering company in San Francisco, California, is interested in securing Coast or California representation of specialty and commodity products of Eastern manufacturers, for which there is an established market on the Coast. Box 12.

Peritonitis Fatal to R. S. Lord

Raymond Sterling Lord, president of the Hope Engineering Company, Mount Vernon, Ohio, died February 12, 1933, at Mount Vernon Hospital-Sanitarium of peritonitis, which developed following an operation for appendicitis.

Mr. Lord was born April 16, 1873, at Conneautville, Pa. During his business career that covered a period of more than 30 years, he was identified with several concerns, but with the organization of the Hope Engineering Company in 1906, Mr. Lord was made secretary, treasurer and general manager, with offices in Pittsburgh. In 1915, he came to Mount Vernon to take charge of the Hope Forge & Machine Company, a subsidiary of the Hope Engineering & Supply Company. He became president of the Hope Engineering Company in 1922 and was still serving in that capacity when stricken.

Byron Jackson Moves Mid-Continent Office to Fort Worth

According to an announcement by Robert Schurman, vice-president, Byron Jackson Co., Berkeley, Calif., the Tulsa office will be moved to Fort Worth, Texas, where it will be located at 2505 Boaz Street.

Several changes have been made in the personnel of the company, which will transfer L. C. Fay, formerly Tulsa manager, to New York City. Lynn Sawyer, heretofore in the company's general headquarters at Berkeley, will succeed Mr. Fay and will be located at the Fort Worth address.

Petroleum Register Purchased by Petroleum Register Corporation

The *Petroleum Register*, international directory of the oil industry, has recently been purchased by the Petroleum Register Corporation, 165 Broadway, New York, from the Chilton Class Journal Company, Philadelphia, Pa. The 1933 issue, which will be the fifteenth annual edition, is now being compiled. The publishers are asking that data relative to companies in all branches of the industry be submitted by interested company officials at their earliest convenience in order to facilitate the work of compilation. All information contained in this issue is being published without charge for such listings. The *Petroleum Register* has no connection with any other publication of a similar nature.

Southwestern District A. P. I. Division of Production Spring Meeting Announced

The spring meeting of the Southwestern District of the A. P. I. Division of Production will be held in Houston, Texas, at the Rice Hotel, on April 7th and 8th, according to advices received from the chairman, Blaine Johnston, vice-president of the Simms Oil Company, Dallas, Texas.

The meeting will consist of two sessions on April 7th and one morning session on April 8th. Particular attention will be given to drilling and production problems in the Gulf Coast area. It is proposed to have papers dealing with recent improvements in setting up and dismantling rotary rigs, as well as drilling and completing high pressure wells in the Gulf Coast. A description of the methods and equipment used when drilling in deep open water is under consideration, particularly at Lake Beret, La.

It is also proposed to describe the pneumatic pumping lift now in use in the Van field, as well as a description of acid treatment of lime formations. An analysis of the various types of bottom hole pressure bombs is also under consideration, as well as a special study of rotary drilling fluids.

Changing A Pump Saved $59.18 Per Day

WHAT'S happened to every other superintendent must have happened to you. During the forty years in which we have served the oil industry, our representatives have probably called on you. They may have suggested changing a pump in some particular field.

Maybe the suggestions they make involve increased barrels per day. Perhaps longer pumping life. Or, again, they may involve operating savings. Regardless of what the idea may accomplish, the reason behind it is a sincere desire to be of service.

Two months ago Fred Winch* over at Seminole put in an Axelson 2½"x10". Last month he wrote us a letter showing how that pump had saved him $59.18 per day.

You may not know Fred Winch* or you may not agree with him, but we are sure you would be interested in his report. It is one of the 67 new reports which we have just prepared on economical pumping. We will bet you a new hat that you won't disagree with all of them. May we send them to you?

*Fictitious Names.

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Mid-Continent Representatives:
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Great Northern Tool & Supply Co.
Norvell-Wilder Supply Corp.

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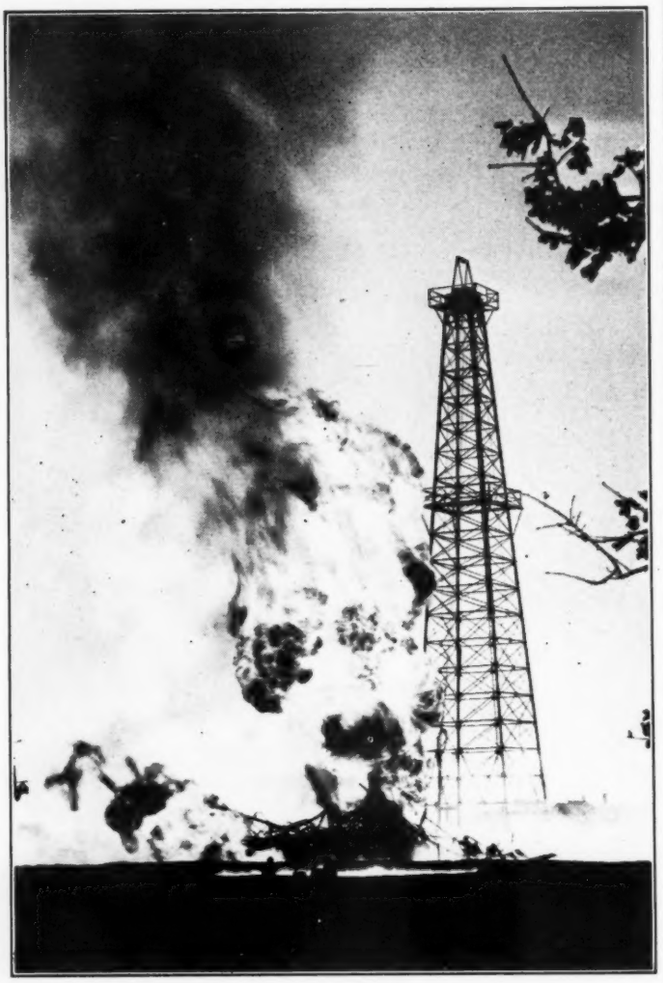
AXELSON GROOVED SEAL INSERT PUMP

Its chief advantage lies in the fact that it offers a larger inside diameter for the same size tubing than any other insert pump. The barrel portion consists of a steel tubing, while the plunger section is made up of cast iron liners. Each of these liners is grooved, the grooves being bevelled so that they approach the action of cups in their operation. Axelson Groove Seal Pumps are furnished in one standard length and four different sizes.

Experience Always Pays



Deep Rock Well No. 2, Wewoka, Oklahoma, flowing 50,000,000 cubic feet of gas and 4,500 barrels of oil a day.

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This Company called the M. M. Kinley Company and in 56 hours had the fire out and well under control.

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TULSA, OKLAHOMA

Specializing in

CAPPING WILD WELLS
EXTINGUISHING WELL FIRES

Some Factors in Extinguish

By M. M. KINLEY☆

NO matter how elaborate the precautions taken to prevent their occurrence, oil well fires still are among the attendant dangers in drilling for oil or gas. Great improvements in drilling practices the last few years have done much toward lessening this hazard. For the most part these improvements have been in the adoption of equipment of advanced design for maintaining control of the well at all times while drilling and in emergencies. Even with this equipment, the unexpected will happen. Conditions will be suddenly encountered wherein the forces of nature will break loose and out of control, frequently causing a well to become a blazing torch.

A mishap of this kind is something entirely different from the normal difficulties that arise in routine drilling operations. Not infrequently, when a well catches fire, the drilling superintendent and the field engineer are suddenly confronted with a problem of a type neither has ever before been up against. It is an emergency that calls for quick, decisive action, and for clear and sound thinking. Experience in successfully coping with such conditions counts for much. For this reason, and because of the expense and danger in extinguishing a blazing well, to say nothing of the extreme hazard that capping of the well entails after the fire is out, a burning well, of all things, is most dreaded by superintendents and all field men.

One may sit back and devise all kinds of devices and means for extinguishing the fire, but when it comes to applying these, it is a different story. It means working in an area very close to the flames and demands, besides a cool nerve, skill, judgment and experience of a highly specialized type. It is one of those difficult tasks wherein experience plays a large and very important part.

About the best that can usually be done by the field officials in charge is to adopt some emergency measures until the expert fire-fighters arrive on the scene, just as first aid is rendered to an injured man until the doctor arrives to administer proper treatment. So far as it is possible, the emergency measures should have as their object the confining of the blaze to the well and the prevention of the spread of the fire to other wells or surrounding property. Handled in this manner the job of extinguishing a burning well and bringing it under control can be greatly expedited.

After having extinguished many oil well fires, the writer and his brother know what a problem it is, when called in to put out a well fire, to be confronted with a host of suggestions and ideas for extinguishing the blaze and to attempt to give consideration to, and analyse the merits of the ideas put forth on such occasions. Though many of them may have merit, it is wise to choose the plan that seems most feasible and carry it through to completion, rather than try to follow several impractical, untried ideas, a procedure that usually results in hampering the successful completion of the task in hand, thus causing delays that are costly.

For example, several years ago an oil company having an interest in a well in Arkansas that had caught fire called us in to extinguish the blaze and get the well under control. On arrival at the well, it was found that, instead of being in

☆ M. M. Kinley Company, Tulsa, Okla.

uishing Oil Well Fires

the hands of the company the well was really in charge of the drilling contractor, who had a turn-key drilling contract to complete the well and who, therefore, was on the job attempting to extinguish the fire as best he could. There were several tool-pushers, each with a different idea and each trying to use his own plan to put the fire out. As a result, there was a lot of confusion and lost motion, and all efforts to check the blaze had failed.

Since the oil company was not in full authority, we tried to please each tool-pusher by trying his plan. After working several days and accomplishing nothing, we recommended that a long hook be made so that the master gate could be pulled off, thereby confining the fire to the column of flame that shot from the well. Finally, at the end of the sixth day, the hook was made and used successfully. It was only a few hours from the time the master gate was pulled off the casing until the fire was out. In this instance, had the job been under the direction of an experienced head having full authority it could have been completed in a much shorter time and with far less expense to the operator.

The old saying that "experience pays" is a good one to observe, for it counts most in having the ability to employ the cheapest, safest and most reliable means in a job of this kind. If one were going to erect a skyscraper, the first architect or contractor to come along would not be given the job; instead, the best available talent in these professions would be sought. To put out a well fire or bring a wild well under control successfully it is just as important to obtain the services of an expert, rather than rely wholly on company men who may not have had any experience in fighting well fires. It seems unfair to expect company men to fight well fires unaided.

The operating companies should also recognize the fact that an expert fire-fighter takes all the risk away from the oil company in regard to the hazards of working around the fire. This fact in itself should be a great inducement to the oil company to get someone outside of its own organization for such work.

The first requirement in fighting an oil well fire is the task of removing all the steel debris, which is one of the most difficult and hazardous jobs. The metal may be red hot and may have fallen over the hole in so twisted a mass as to cause the flames to spread to such an extent that it is a problem to work among the wreckage. In such cases, all the available resources, such as metal shields, water, and even the wind, are called into use. The expert, from past experience, will be able to use these resources to their best advantage so that the work may be completed in the shortest possible time.

After the steel debris has been withdrawn to a sufficient distance that its heat will not cause re-ignition of the oil or gas, the actual work of extinguishing the fire may be started. While explosives have been the most successful means of putting out fires, under certain conditions, they should not be used, as, for instance, in the East Texas field, where, after the fire has been extinguished, the danger in capping the well is very great. The explosive method, therefore, cannot be relied upon exclusively and frequently new, practical methods to suit particular conditions must be applied.

In many fires, unusual or entirely different conditions not theretofore encountered are to be found. These only add to the difficulties and particularly demand the direction of an experienced man at all times.

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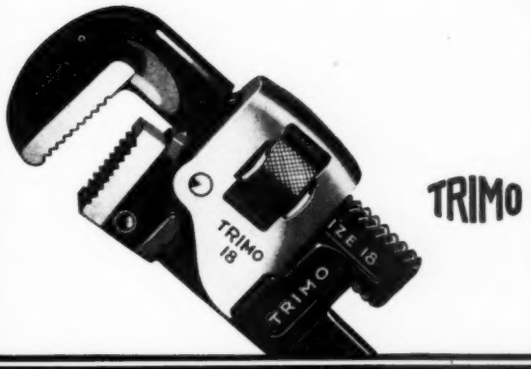

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THE thread is the thing in couplings. When transmission lines have to be made up and broken down time and time again it's the threads that have to be right. Harrisburg couplings have accurate, electro-galvanized threads. Their joints, by test, furnish maximum ductility and tensile strength. • Sales Representatives: W. P. Paul Co., Philadelphia; W. R. McDonough Co., Cleveland; S. C. Mead, Chicago; Mid-Continent Supply Co., Fort Worth; Ducommun Corporation, Los Angeles.

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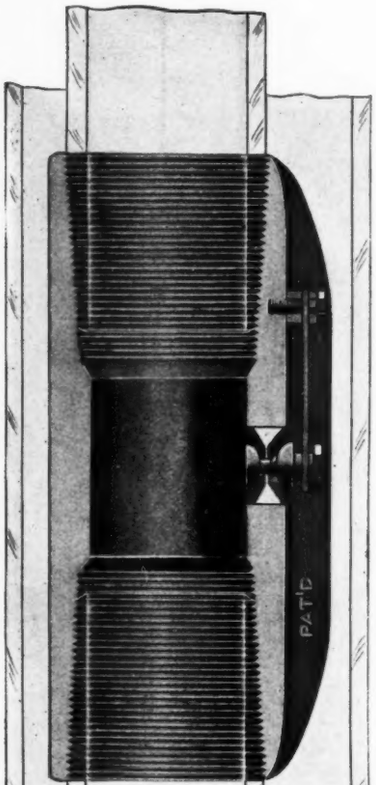

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CARE OF SAFETY VA

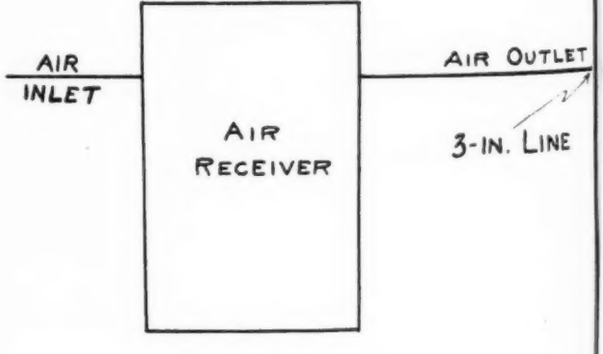
ALTHOUGH the oil industry prides itself on the observance of safe practices in the operation of its hazardous plants, the fact remains that disasters still do occur. It has been impossible actually to determine the true cause of most of these accidents; and in the few instances where the cause is determined, usually the evidence and facts have been withheld. As a result, the industry as a whole has not been able to profit by such failures and so take further precautions to guard against their recurrence.

Were the truth known, many of these unexplained explosions that have resulted in casualties and in serious property losses could be traced to a piece of protective equipment—the writers refer to safety valves. How much thought is given these essential devices by the management and designers in their selection for the service conditions? Sometimes very little, it must reluctantly be admitted. The size of the valve is usually given, based on precedent, together with the desired relieving pressure and perhaps the blow-down range, and, more recently, possibly the materials of construction. Most certainly the specifications, if such they may be called, do not fall in the same category, for example, as those issued for a centrifugal pump, which involve a preliminary study of the operating conditions. The mere fact that a safety valve is installed on a piece of refinery equipment seems satisfactory; and possibly is so, from a psychological standpoint. A safety valve may not be, however, all that the name implies unless it is given proper chances of performing its duty.

The operating and maintenance personnel follows the lead of the management and readily accepts the safety valve at its face value, and even goes so far as to give it less attention than that given similar valves on steam service in the same refinery. A centrifugal pump, on the other hand, is constantly checked as regards bearings and lubricant, and should leakage occur at the glands, immediate steps are taken to correct this condition. As for the safety valve, it receives hardly a thought or a glance in the ordinary routine of operation, yet its failure to function when required may result in a disaster unparalleled by the failure of any other piece of equipment in the plant.

Hot water tanks in our homes are generally protected by spring-loaded relief or safety valves of the same general design as those used on tanks or containers for hydrocarbon fluids at any gasoline plant or refinery. When such a spring-loaded valve leaks, many plumbers will screw the adjusting nut down until the valve stops leaking, little realizing that they may be setting the valve to release the pressure at many

Diagrammatic Sketch of arrangement for testing safety valves



VALVES » » » »

By F. L. KALLAM AND C. C. STEWARD
Refinery Engineers

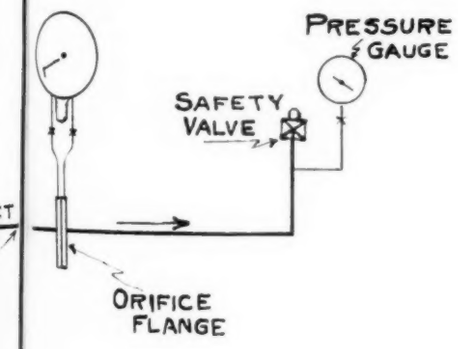
times the bursting pressure of the tank or heater that it is desired to protect. Who has not likewise seen a gasoline plant operator at one time or another adjusting a safety valve in the same fashion?

Following an explosion in a plant that resulted in a serious fire, the safety valves from the gasoline storage tanks, on examination, were found intact. Having failed to establish definitely the cause of the explosion, the valves were subjected to a hydrostatic pressure test in a last desperate attempt to determine the cause of the trouble. The results were astonishing. As the recovered valves had been subjected to high temperature and pressure, and possibly severe strains, the results were not considered conclusive, so the original order for valves was then duplicated, using the original purchase specifications, and further tests made. It is felt that these tests, with their conclusive results, warrant a detailed account of the procedure followed in making the tests and the findings.

The testing apparatus was a 3-inch line equipped with an air orifice plate having flanged connections, the latter being piped to a recording differential pressure gauge and a static pressure gauge. This line was connected to a large 250-lb. air chamber, and the safety valve, with suitable pressure gauges, installed at the opposite end of the orifice set-up. By this arrangement the valve capacities were determined for various pressures, which feature of the tests will not be considered at present.

Air pressure was applied to the testing apparatus, and at a pressure of 19.5 lb. per sq. in. the first safety valve tested released the air to the atmosphere. After the valve opened, the pressure in the line gradually diminished, but the valve continued to remain open, discharging air from the system as rapidly as it could be supplied from the receiver. Screwing the adjusting stem of the valve down did not entirely stop the flow, so the adjusting stem was loosened, allowing the valve to open wide. As it did so, small particles of dirt and pipe scale were discharged with the air. When the line appeared to be cleaned out, the steam was again set in its original position, and the pressure allowed to rise. At a pressure of 19.5 lb. per sq. in. the valve again opened, but snapped shut again when the pressure dropped to 18.5 lb. per sq. inch.

Obviously, the trouble was due to scale lodging under the seat after the valve first opened, thus preventing its closure.



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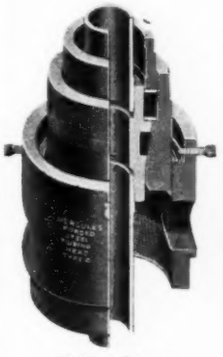
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The valve has a definite positive movement for a definite change in discharge pressure, and will remain indefinitely at some intermediate position between the wide open and closed position.

Excess discharge pressure flows through this regulator *without noticeable variation.*

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Manufacturers of Regulators for all Natural and Manufactured Gas Services

28-40 PENN AVE. PITTSBURGH, PA.

A CORRECTION

IN the November 15, 1932, issue of this magazine, we inserted an advertisement, over our name and that of the Baroid Sales Company, concerning a patent decision involving Stroud patent 1,575,945, owned by us. The advertisement referred to carried the following statement:

> "Baroid is the only oil well drilling mud weighting material which is licensed for sale or use under this patent."

This statement was inaccurate in that we failed to mention that C. K. Williams & Company, of Easton, Pennsylvania, (and their subsidiaries) are licensed by us, under the Stroud patent, to make and sell IRON OXIDE for use as a weighting material in the drilling of oil and gas wells, and the users of their product are fully protected under that patent.

We are making this correction in justice to C. K. Williams & Company and to clear up any wrong impression which may have been given by the original statement.

NATIONAL PIGMENTS & CHEMICAL COMPANY

ST. LOUIS, MISSOURI

As a matter of fact, the valve could not be closed completely regardless of the amount the spring was compressed by the adjusting nut. As soon as the scale was removed, the valve was readily adjusted to open and close at the desired pressures.

The adjusting nut was screwed down until the stem was against the lock-nut. The valve now opened at a pressure of 68 lb. per sq. in. and closed at 66 lb. per sq. in. It should be remembered that each valve tested bore the manufacturer's stamp, showing the setting for the valve to be 20 lb. per sq. in.

In a similar fashion, all the remaining seven valves were tried, and in no case did a valve remain open below the desired pressure. All, however, showed a tendency to relieve at much higher pressures than the set rating when the adjusting stems were screwed down. These pressures varied from 68 lb. per sq. in. for the first one tested to 172 lb. per sq. in., which was the maximum. The valve that showed the maximum pressure closed off at 165 lb. per sq. in. when the setting of the spring tension was greatest. It should be borne in mind that these valves had been purchased to protest tanks of 18 lb. per sq. in. working pressures.

The writers conclude that a common cause of safety valve failure is due to line scale or sediment lodging under the valve seat, thus preventing full closure, or to scoring of the seats to the extent that complete closure is impossible. To flush the valve, or obtain the desired pressure when the seats are scored, the pressure adjustment must not be disturbed, a condition that necessitates resetting of the valve under field operating conditions. This is a dangerous practice, and to avoid it, it is absolutely essential during the period of construction to clean and blow out all lines and connections that are to carry safety valves. This should be done before the valves are attached.

In no case should an operator be authorized to tamper with or re-adjust safety valves in the field, for in so doing, he may increase the relieving pressure of the valve to the point where all protection is lost, with the result that instead of acting as a safety device, the valve actually introduces a hazard into the system. This is particularly true in the case where a new plant is to be started, and emphasizes the necessity of having the operation directly in charge of a competent supervising engineer.

Manufacturers of safety valves can be relied upon to supply valves correctly set as marked, and meet the specifications of the purchaser. It is not the intention of the manufacturer, however, that valves be readjusted except within a very narrow setting range, although there is nothing to prevent other degrees of adjustment with the conventional valve. Safety, therefore, demands that relief valves be purchased with stems cut so that when they are completely screwed down, the relieving pressure cannot be made to exceed the specified relieving pressure by more than 5 per cent. Such procedure forestalls any possibility of raising the relieving pressure to a dangerous point, even should field adjustment be resorted to. Should plant conditions be changed so that a higher relieving pressure is required, the safety valve must either be replaced, or new calibrated springs installed. Compliance with these requirements makes for safe and sure operating safety valves.

Natural Gasoline Supply Men Elect Officers

At the Board of Directors meeting, January 30, the following men were elected officers of the Natural Gasoline Supply Men's Association: W. D. Moorer, president; B. W. Vinson, first vice-president; A. V. B. Candler, second vice-president, and M. H. Kotzebue, treasurer.

Atlantic Installs Refrigeration Room in Pittsburgh Testing Laboratory

Adaption of the principles of household refrigeration to the extraordinary temperature demands of an oil testing laboratory has been successfully achieved in equipment installed in the Pittsburgh testing laboratories of the Atlantic Refining Company by Frigidaire Corporation, subsidiary of General Motors.

The refrigeration equipment provides simultaneously in different compartments temperatures ranging from freezing down to 60 degrees below zero. It is used for testing motor lubricants for the most severe climatic conditions under which automobiles and airplanes might be called upon to operate.

A storage chest, in which oils to go under test are placed preliminary to the actual test runs, is held at 32 deg. fahr., according to W. S, Dingfelder, refrigeration engineer, who worked out the equipment. Adjacent to this is a cabinet consisting of two sections insulated with 6 in. of cork. One section has six compartments surrounded by brine carried at 15 degrees above zero. The second section has four sleeve compartments held at 25 degrees below zero.

An individual compartment 10 in. by 2 in. inside dimensions is held at 60 degrees below zero for the final testing of lubricants. The equipment is refrigerated by a standard commercial refrigeration compressor with an A.S.R.E. rating of 4/10 ton.

Carl Anderson Loses Life in Auto Crash

Carl Anderson, 1707 South Florence Ave., Tulsa, Okla., Mid-Continent representative for A. Leschen & Sons Rope Co., St. Louis, Mo., was fatally injured February 15, when his automobile ran off a bridge near Edmond, Okla. He was en route from Oklahoma City to spend his fortieth birthday with his family when the accident occurred. Mr. Anderson was well known in the oil industry, having been connected with it for many years.

Appoint A.P.I. Sub-Committee on Methods of Testing Crude

Appointment of the American Petroleum Institute's 1933 Technical Sub-Committee on Methods of Test for Crude Oil has been announced by Charles F. Roeser, chairman of the Institute's Division of Production. The sub-committee functions under the Central Committee on measuring, sampling and testing of crude oil.

Dr. R. P. Anderson of the Institute staff, is national chairman. Area chairmen are: Eastern, L. W. Parsons, Tide Water Oil Co., Bayonne, N. J.; Oklahoma-Kansas, H. W. Camp, Empire Oil & Refining Co., Tulsa, Okla.; Rocky Mountain, P. G. Weidner, Midwest Refining Co., Casper, Wyo.; Texas-Louisiana-Arkansas, E. R. Lederer, Texas Pacific Coal & Oil Company, Fort Worth, Tex.; and California, J. B. Terry, Standard Oil Co. of California, Richmond, Calif.

Auto Accident Fatal to Guy O. Danielson

Guy O. Danielson, representative of the Chicago Pneumatic Tool Company in the Gulf Coast area, died February 10 at Houston, Texas, from injuries received in an automobile accident a week previous. Mr. Danielson was, during his long affiliation with the petroleum industry, identified with the Gulf Pipe Line Company and the Brauer Machine & Supply Company of Oklahoma City, Okla.

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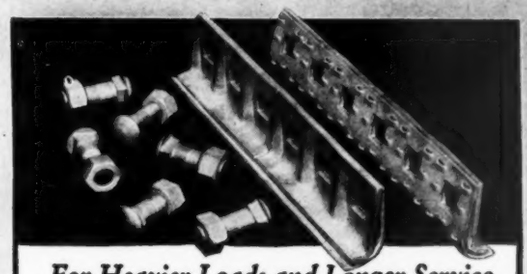

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By HAL T. WHEELER
Mechanical Engineer

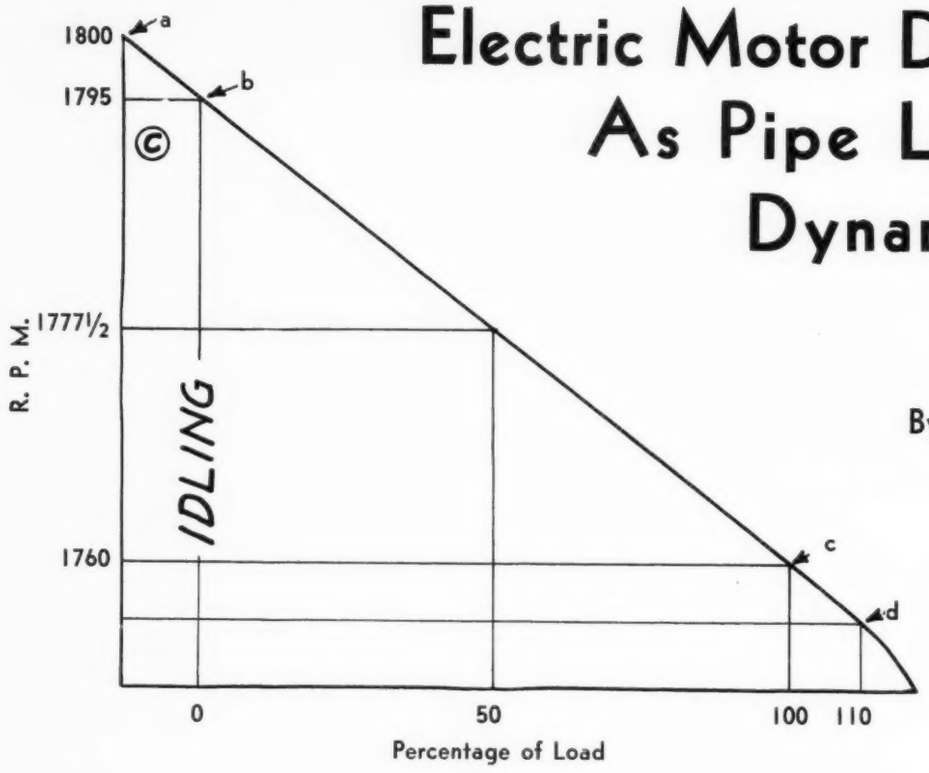

Chart 1, showing relationship between r.p.m. and percentage of power produced.

THE energy consumed by a machine in producing power is measured by some form of precision instrument. A flow meter connected across an orifice in a steam lead will record the pounds per hour of evaporated water used by any steam unit. A recording watt-meter in the leads to an electric motor will register the incoming energy. But what happens to this energy? It should be apparent that the measurement of incoming energy will enable the engineer to compute the costs of running a unit. But this method does not indicate or record what that unit does in transferring the energy into useful work.

The power generated by a machine, for example, an electric motor direct connected to a centrifugal pump, is expended on many things: the work done by the impeller in lifting a column of liquid, overcoming the friction of the bearings, overcoming resistance at the coupling, overcoming friction of the packing, and the like. There are many excellent curves and charts that show what the unit ought to do when in the best mechanical condition. But when it fails to run efficiently, how is the operator to know what is causing the loss?

When a motor is too small to carry the load it will overheat and it is logical to install a larger one. But if the motor is too large, how much too large? Or if the motor is known to be of the correct capacity and still fails to operate satisfactorily, what element is taking an undue share of the available power?

The use of precision instruments has been restricted because of initial cost. Neither are laboratory methods during operation very popular, as the interruption resulting is usually more costly than the worth of the information gained. What is more desirable is a quick method by which the operator can gain an insight into the condition.

An excellent example of mechanical efficiency found in almost every plant today is the alternating-current motor. An understanding of its operating characteristics, the information that the manufacturer gives on the name plate, and some simple readings as to speed are sufficient to make an approximate determination of what any such motor is doing. An alternating-current motor is an accurate indicator of the amount of power being drawn from it.

Consider the synchronous or theoretical speed of a motor calculated from the number of poles and the frequency of the line. A four-pole motor operating on 60 cycles is known as an 1800-r.p.m. machine when there is no connected load, and is so stamped on the name plate. A tachometer, or direct-reading r.p.m. indicator, can be used to verify the apparent speed rating. A revolution counter held in the motor shaft center to observe the number of turns made during several minutes and timed by a stop-watch will show that an 1800-r.p.m. motor actually turns from 1795 to 1796 r.p.m. The direct-reading instrument will not show this small loss in speed, which is due to windage and to bearing friction. Table 1 shows the revolutions of the standard motors as they have been found by actual count, the motors being in fair mechanical condition and the frequency of 60 cycles being constant.

Table 1

Rated r.p.m. - - -	600	900	1200	1800	3600
Idling speed - - -	598	897	1196	1795	3590

The next item necessary for the use of this method is the speed of the motor when it is fully loaded at its rated horsepower. This may be found on the name plate and is for this example 1760 r.p.m.

Chart 1 shows the relationship between r.p.m. and the percentage of the power produced. The ordinates are the r.p.m., the abcissas the percentage of the rated load, 100 per cent representing the horsepower at full load. Point "a" is zero load and is theoretically possible at 1800 r.p.m., but due to windage and shaft friction is never attained. Point "b" is the idling-load speed with all load disconnected and as actually measured is 1795 r.p.m. Point "c" is the manufacturer's full-load speed stamped on the name plate and in this example is 1760 r.p.m.

Manufacturers' Rating and Some Simple Readings as to Speed Are Sufficient to Determine the Relative Losses Due to Worn Packing or Shaft Wear » »

Modern alternating-current motors have certain speed-load characteristics. They are so designed that the speed falls proportionally as the load increases (up to an overload point to be mentioned elsewhere). This being so, a straight line can be drawn from point "a," theoretical zero load at 1800 r.p.m., to point "c," full load at 1760 r.p.m. Not only will point "b," the idling load at 1795 r.p.m., be on this straight line, but also every speed corresponding to any load percentage. For example, 50 per cent of the load will occur at 1777½ r.p.m. For overloading as point "d," a 110 per cent load, the straight-line relationship begins to fail, the curve changing rapidly. It is therefore advisable not to depend on this method for loads greater than 10 per cent over the maximum name plate rating.

By assembling the foregoing information in the manner described any operator is in a position to determine relatively how much power a motor is producing.

Suppose that it is required to measure the power consumption of two sets of packing on a centrifugal pump shaft directly connected to the 1800 r.p.m. motor of this example. It is further assumed that the motor will develop 10 hp. at 1760 r.p.m. Chart 2 is a reproduction of Chart 1. The speed of the motor is taken by a tachometer (direct reading) and found to be 1770 r.p.m. with the packing not leaking, point "f." Both packing glands are then loosened until they leak freely, the speed at this point being 1775 r.p.m., point "e," a gain of five revolutions. As the motor speed has been shown to fall from 1795 to 1760 r.p.m, or 35 revolutions, while producing at the rate of 10 hp., the gain of five revolutions represents one-seventh of the rated power or ten-sevenths (1.43) hp., the power necessary to overcome packing friction when the packing is tight.

Few realize the power necessary to pull the softest packing on an eccentric pump sleeve. An eccentricity of $\frac{1}{32}$-in. in shaft or sleeve is usually passed as satisfactory and not worth changing. For those who would learn the facts, let them install a new set of packing on an old lop-sided sleeve and take the r.p.m. under load and plot the result on Chart 2. Then remove the pump shaft and true it up on lathe centers and again take the speed after refitting with the same kind of packing. The reduction in consumption of power observed will convince any one that to replace the packing frequently is cheaper than paying for the excess power used by a cut sleeve.

A similar case is that of a vibrating shaft. In a former article *The Petroleum Engineer*, page 52, December, 1932, issue, the limits of safe vibration within which packing should be used were given in thousandths of an inch and an instrument for taking such measurements was described. The power consumed by a shaft traveling within the range of limits set is far more in proportion than the increase of the vibration. For example, take the speed reading of a pump shaft that is running smoothly. Then throw the shaft out of balance by a weight attached to one side of it. A comparison of the difference in power consumption will show that vibrating pump shafts are to be avoided.

In like manner, the relative methods of horsepower output may be used during the alignment of bearings, the testing of parallelism of shafts, the change of shaft position due to expansion and contraction of casings, the conditions of bearings, and so on.

When is a pump "overpowered"? After an installation is made it is customary to assume that because the motor is taking care of the load requirements the combination is satisfactory. For a constant load, however, the motor should be running at the full-load speed stamped on the name plate. If it is running faster, the motor is too large and the degree of waste should govern the advisability of changing to a smaller one. If a maximum load is carried intermittently by the motors its speed should be checked during the interval of highest load. There are far more overpowered than underpowered installations because it will be immediately indicated by overheating that the motor is too small.

After a group of motors have been checked and it is found that some of them may, with advantage, be changed, then the total horsepower required may be transferred to current consumption after allowing for efficiencies of the units. Often it is found that a waste occurs by continuing to use the sizes of wire that apparently were correct on the original installation.

The condition of a constant speed combination has been used for the example. There are many other motor-driven installations, as chain and belt drives to reciprocating pipe line pumps and to air compressors, that may be checked accurately by the methods of Chart 2. As there is usually a surge in such motor combinations, the direct-reading tachometer may not give a correct average. In such cases a tachometer with a recording chart attached may be used to average the revolutions per minute. A simpler method is to obtain a constant load, then take the revolutions of the motor for several minutes and average the results.

The electric motor is a dependable unit in any station. Despite the abuse to which it is subjected, it will always indicate its power output and in addition can be used as a measuring device for comparing relatively the components of the load to which it is connected. The motor can serve as a power-measuring instrument that the engineer may consult without danger of interfering with operation.

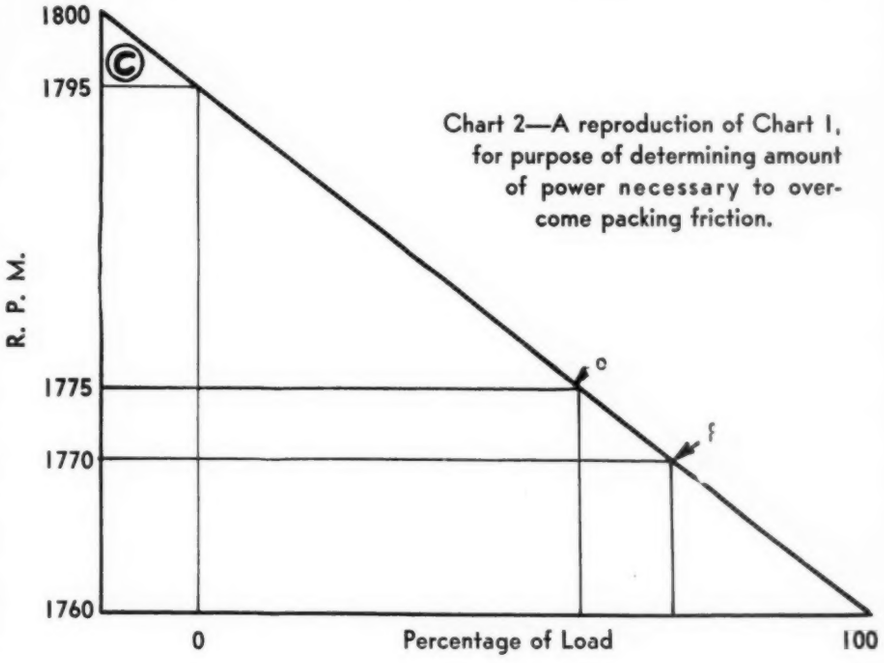

Chart 2—A reproduction of Chart 1, for purpose of determining amount of power necessary to overcome packing friction.

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THE NEWARK WIRE CLOTH COMPANY, 351-365 Verona Avenue, Newark, N. J., manufacturer of wire cloth of all meshes, weaves and metals for all industries, has issued a six-page folder which is devoted entirely to two of their products: their new End-Shak Testing Sieve Shaker and their U. S. Standard and A.S.T.M. Standard Cornerless Testing Sieves. The folder contains valuable descriptive matter, tables, etc., on Newark Testing Sieves and on the End-Shak machine which is not obtainable elsewhere in concentrated form. A copy will be sent upon request to any reader of this publication.

A NEW sixteen-page vocational booklet, entitled "The FWD Six Wheeler in Milk and Oil Service," has just been published by the Four Wheel Drive Auto Company of Clintonville, Wis. This booklet stresses the claims of greater safety, greater range of operation and greater economy made by the manufacturers and illustrates these points with drawings and photographs.

In illustrating the safety angle, some of the features brought out are the higher average road speed which can be maintained due to absence of skidding or sluing on corners and slippery roads. Drive to the front wheels and additional load on the steering axle are credited as responsible for this fact. Six wheel air brakes and the low center of gravity are the two other contributing factors to the safety claimed in this vehicle.

"M-D" HYDROSTATIC SAND PUMP, a new perfected tool for cleaning out sand or junk from oil wells, is fully described in a new bulletin published by the manufacturers, Martin-Decker Development Company, Ltd., Long Beach, Calif. It is designed to utilize the entire force of the hydrostatic pressure of the fluid in the well to drive the sand, cavings or junk directly into the pump.

G-R G-FIN STORAGE TANK OIL HEATER, a new product of the Griscom-Russell Company, 285 Madison Avenue, New York City, is described in a new leaflet known as Form 484. This apparatus is used for heating viscous oil to be withdrawn from field tanks, tanks on shipboard and other types of oil storage tanks.

Walter F. Perkins, who has been manager of the Harrison, New Jersey, works of the Worthington Pump and Machinery Corporation since 1927, has resigned to become vice-president and general manager of The Bartlett Hayward Company, Baltimore, Md., where he assumed his new duties on December 1st. Mr. Perkins is succeeded as works manager at Harrison by Mr. Hugh Benet, who was formerly manager of Worthington's Holyoke, Mass., works.

CHEMISTRY AND TECHNOLOGY OF CRACKING by Sachanen and Tilicheyev of the Petroleum Research Institute of Grozneft has been published by the Chemical Catalogue Co., New York City. A price of $8 has been placed on this valuable reference book for the refinery chemist or engineer. Chapters deal with the fundamental features of cracking, the chemistry of cracking, chemical composition of cracked products and other principal topics. The ninth chapter is devoted to hydrogenation.

OXWELD NO. 25-M BRONZE PATENTED WELDING ROD, twenty pages, 3½ x 6, has been published by the Linde Air Products Company, New York.

In this booklet are described the physical and welding characteristics of this new bronze welding rod, with which it is possible to obtain tensile strengths in joining steel of between 56,000 lb. and 60,000 lb. per sq. in. and ductility in excess of 30 per cent. Marked decrease in fuming and excellent weldability are other outstanding characteristics. Many important applications are described in joining metals and building-up wearing surfaces. Of special note are recommendations on a new technique for bronze welding and for the fusion welding of brasses and bronzes; in particular, the proper flame adjustments are described for the various base metals.

THE PITTSBURGH EQUITABLE METER COMPANY has recently issued a 16-page catalogue entitled, "Pittsburgh Oil and Gasoline Meters for Bulk Stations, Refineries, Tank Trucks and Pipe Lines". This bulletin describes and illustrates Pittsburgh Piston Meters, Disc Meters and Eureka Current Type Meters.

AMERICAN SOCIETY FOR TESTING MATERIALS, 1315 Spruce Street, Philadelphia, Pa., has issued a new publication that brings together in convenient form the various A.S.T.M. standard test methods for petroleum and its products and the 1932 Report of Committee D-2 on Petroleum Products and Lubricants. There are forty-eight test methods given, thirty-three having been accepted as standards and fifteen as tentative standards. The complete publication aggregates 280 pages. Copies are available, in heavy paper binding, at a price of $1.25.

GENUINE WROUGHT IRON BILLETS, a new product of the A. M. Byers Company, Pitsburgh, Pa., are fully described in a new four-page pamphlet that may be secured from the company. Byers genuine wrought-iron billets are furnished in all desired sizes so that a minimum of forge shop work is required for the finished product.

FOXBORO BULLETIN NO. 175, is a 32-page, well-illustrated publication presenting the theory and operation of the Stabilog System of automatic control, an engineering development of the year by the Foxboro Company, Foxboro, Mass. Simple, everyday analogies give the reader a readily understandable explanation of Stabilog action and operation.

AUTOMOTIVE FLEET MAINTENANCE BULLETIN issued by the South Bend Lathe Works will be of interest to those producers, refiners and distributors who maintain company repair shops for their automotive equipment. The bulletin is descriptive of servicing operation for brake drums, wheels and hubs. This booklet, called No. 4, may be had by any reader, without obligation by addressing the Technical Service Dept., South Bend Lathe Works, South Bend, Ind., and mentioning the name of this publication.

THE TRACKSON COMPANY, Milwaukee, Wisconsin, announces a new circular, Form No. 323, describing its most recent product, the Trackson 10-13 Yard Bottom Dump Crawler Wagon equipped with the new 20-25 ton Trackson Crawler Wheels, that meets contractors' needs for greater hauling capacity.

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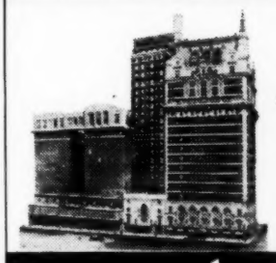

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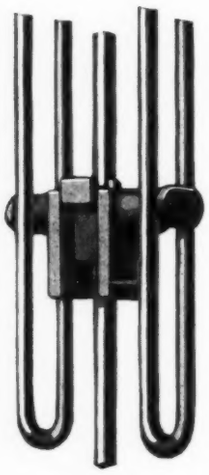

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